he magazine of aerospace technology / SEPT. 1959

space aeronautics

formerly Aviation Age

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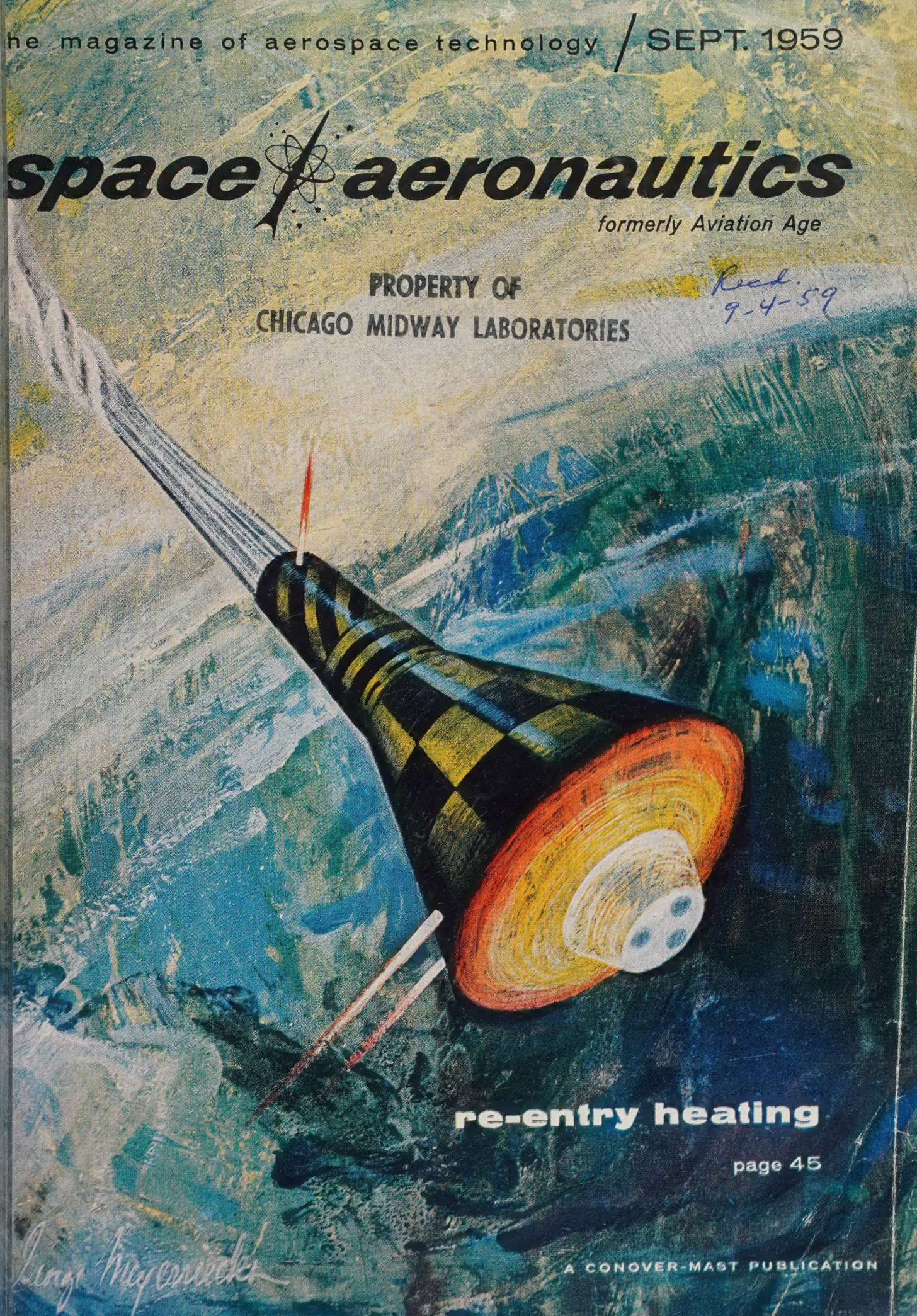


re-entry heating

page 45

A CONOVER-MAST PUBLICATION

Crosley Radar

And . . . . . .

America's defense

Soon the latest in ground radar from Cros will stand watch along the distant approaches to the North American contin Since 1955 Crosley's radar engineers have been at work—designing, perfecting, improving this important new radar unit.

Now the FPS-26 ground radar is ready for production, and Avco's Crosley Divisio has been named prime contractor by the U. S. Air Force.

The huge radar—so new that it is still classified—will be housed in a radome more than 50 feet in diameter. It will be mounted atop a reinforced concrete tower more than 70 feet high and will consist of more than 300,000 parts, including some 3500 tubes and diodes.

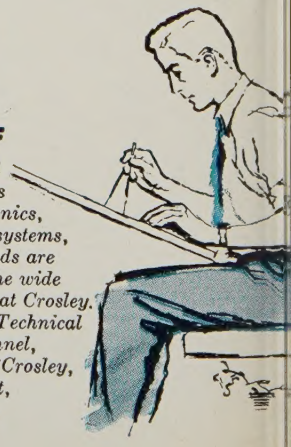
Handling the design and production of complex, challenging radars is "old hat" t Crosley, prime contractor of the famous MPS-16 height finder radar now widely used by the armed forces. Similarly, Crosley now is prime contracto to the Air Force for the radar-directed fir control system that puts a 50-caliber "stinger" in the tail of the B-52 bomber.

Radar is just one example of Crosley kno how in both engineering and production— *designing* the best possible performance in the product . . . *producing* it on schedule, and at a reasonable cost.

Today Crosley is recognized as a leader, not only in radar, but in communications, marine electronics, electronic ground support, infrared, fire control systems, air traffic control, ordnance and missile arming and fuzing.

For more information, write to: Vice Presi Marketing-Defense Products, Crosley Divis Avco Corporation, 1329 Arlington Street, Cincinnati 25, Ohio.

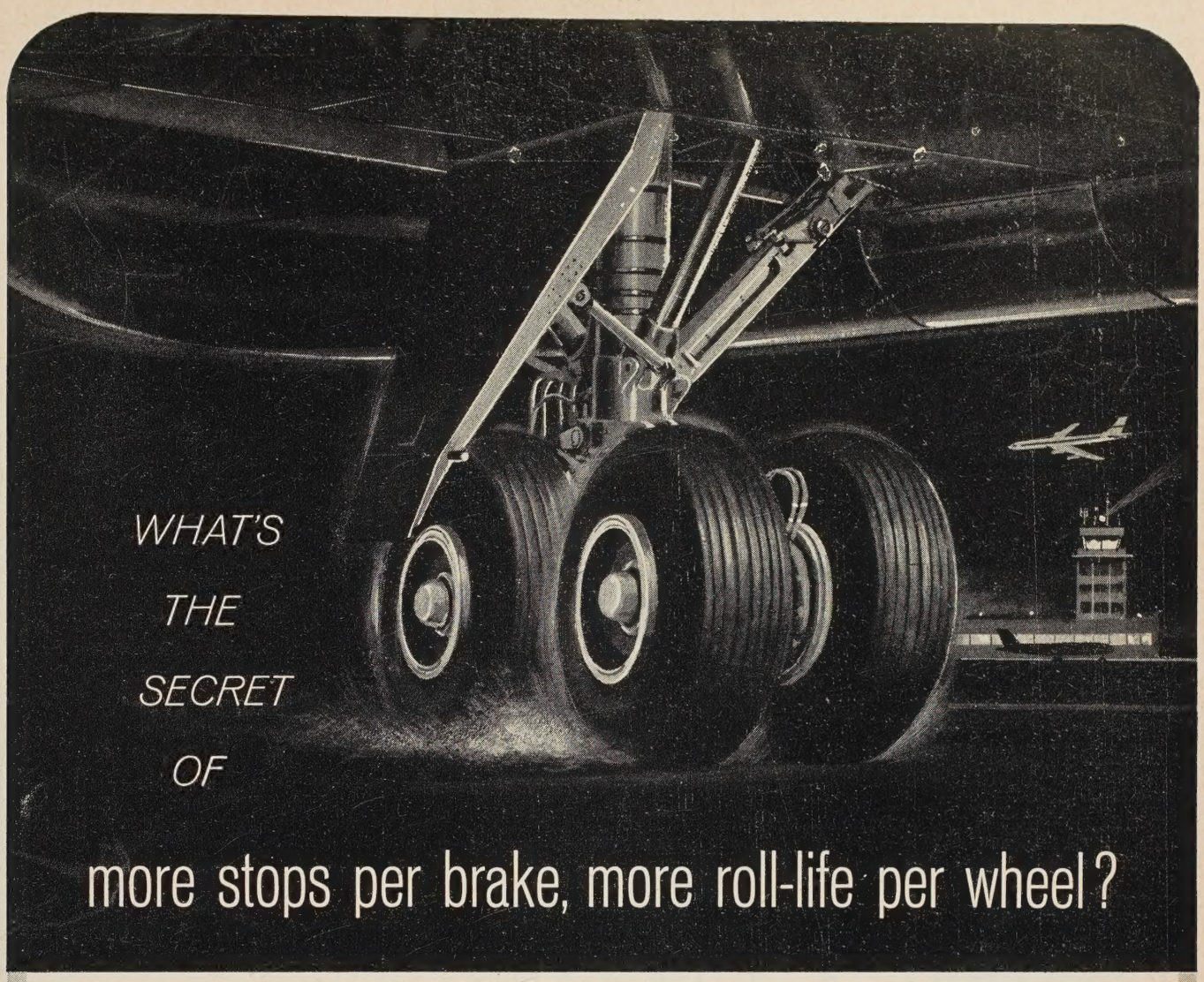
Avco / Crosley



ENGINEERS:

Creative research and development engineers experienced in electronics, mechanics, weapons systems, and ordnance warheads are urged to investigate the wide range of opportunity at Crosley. Write to: Director—Technical and Scientific Personnel, Dept. C-99E, Avco/Crosley, 1329 Arlington Street, Cincinnati 25, Ohio.

ANOTHER "PLUS" FROM GOODYEAR AVIATION RESEARCH



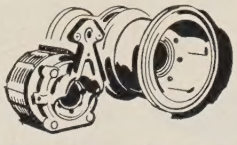
WHAT'S THE SECRET OF more stops per brake, more roll-life per wheel?

First, consider this: Goodyear builds more long-roll-life airplane wheels than all other wheel manufacturers combined. It's also a fact that more aircraft, the world over, rely on Goodyear Aviation Brakes than any other kind. Among the new aircraft that depend on Goodyear Wheels and Brakes: Grumman – A2F-1, W2F-1, YAO; North American – T2J; Convair–B-58, 880; Republic–F-105; Lockheed–JETSTAR; Fairchild–F-27.

What's the secret of this overwhelming preference? From Goodyear engineering leadership, dating back to 1909 when Goodyear built the world's first airplane tire, have come wheels of the greatest strength and longest roll-life per pound of metal ever made. It has also produced the famous disc brake, a pioneer Goodyear development which has set the pattern for more efficient braking in a host of fields.

Latest Goodyear advances include the Tri-Metallic Brake and forged aluminum and magnesium wheels—all unmatched for weight-savings and dependability.

Whatever the aircraft—there's a perfect wheel and brake combination for it from Goodyear, *first choice in its field for 50 years!* Write for full details. Address Goodyear, Aviation Products Division, Akron 16, Ohio, or Los Angeles 54, California.



AVIATION PRODUCTS BY

GOODYEAR

MORE AIRCRAFT LAND ON GOODYEAR TIRES, WHEELS AND BRAKES THAN ON ANY OTHER KIND

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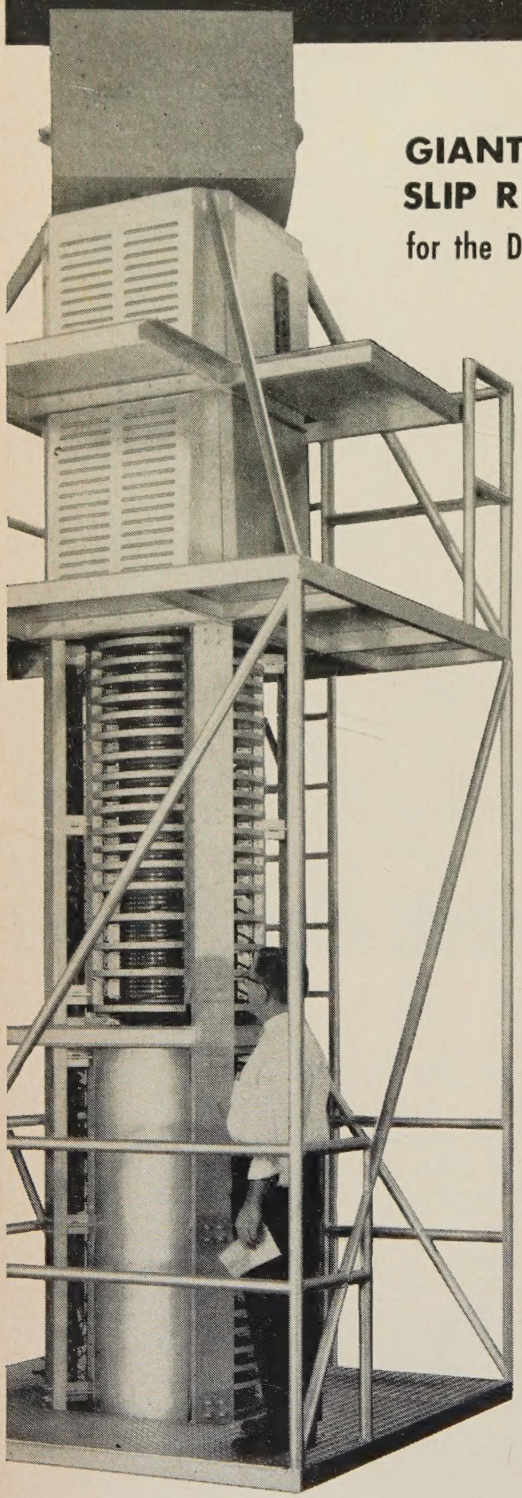
another first from ELECTRO TEC



GIANT PRECISION SLIP RING ASSEMBLY

for the David Taylor Model Basin

WHAT IT DOES — At the David Taylor Model Basin, where "Scale models of today are ships and aircraft of tomorrow," a new addition to the Hydromechanics Laboratory is under construction. Highly specialized and radical hull designs are to be tested in a 260 foot diameter tank. A pylon in the center of the tank supports a 135 foot arm. Below a traveling carriage suspended from the underside of this arm, hull designs are subjected to intricate maneuvers. All stress, torque and other measurements go through the pylon for transmission to computers on the shore. Means was required for the uninterrupted transmission of electrical information through a rotating joint. The slip ring provided by Electro Tec meets the high standards of precision required. Weighing roughly 5,000 lbs., the 16 foot high slip ring assembly consists of 137 circuits for signal, control and power. One power section for operation above 600 V. will conduct 3,000 amperes.

Many other unique problems have been solved with Electro Tec slip rings.* In contrast to the David Taylor giant are units as small as .039 inches in diameter containing 6 circuits. Write for information on individual components or complete assemblies to precise electrical, mechanical and environmental specifications.

*Pat. No. 2,696,570 and other patents pending.

Write Electro Tec Corporation on all your slip ring requirements.

ELECTRO TEC CORP. *Products of Precision Craftsmanship*

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space/aeronautics

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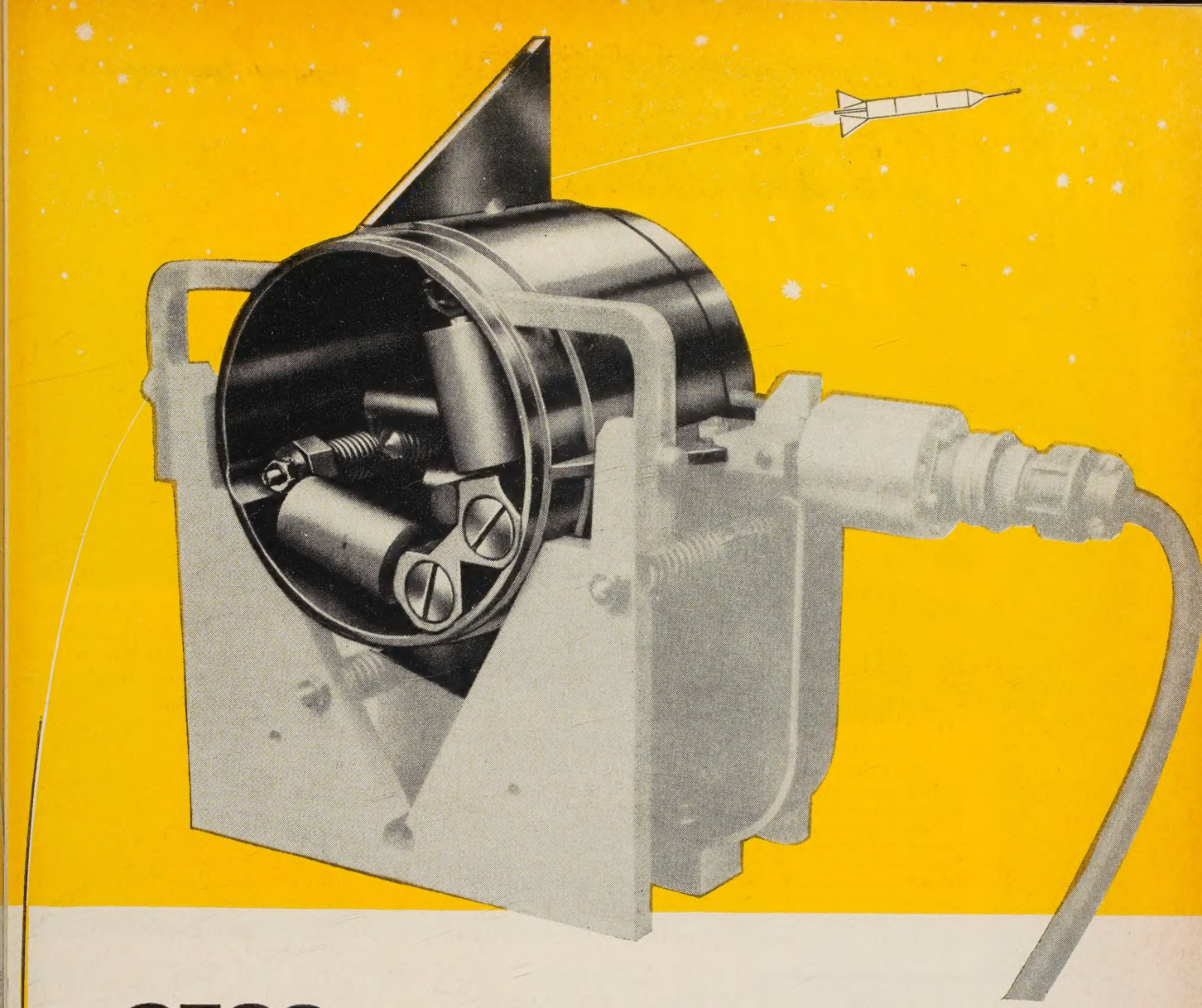

CECO has run HOT GAS SERVO CONTROL SYSTEMS on both solid and liquid propellants

Aided substantially by design and precision manufacturing experience in the field of highly sophisticated gas turbine control systems, Chandler Evans has been furthering the development of high-pressure pneumatic systems for missiles and satellites. Backed by highest technical and analytical skills, work on each new system includes thorough investigation in CECO's well-equipped Computer Laboratory.

Typical of progress made during the past several years is the new guidance control unit shown above in a test rig. A hot gas servo control system fueled by solid charge, it operates with gas inlet temperature in the 1800°F. range. Charge, control hardware and missile section—the entire system weighs only 6.9 lbs.

Reliability, simplicity and readiness capability suit systems like this to a wide range of missile applications.

Contact your nearest CECO Field Engineering Office for cooperation in solving your control system problems.

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For a new folder on CECO hot gas servo control systems, address your request to Department 59.

CECO SYSTEMS CONTROLS

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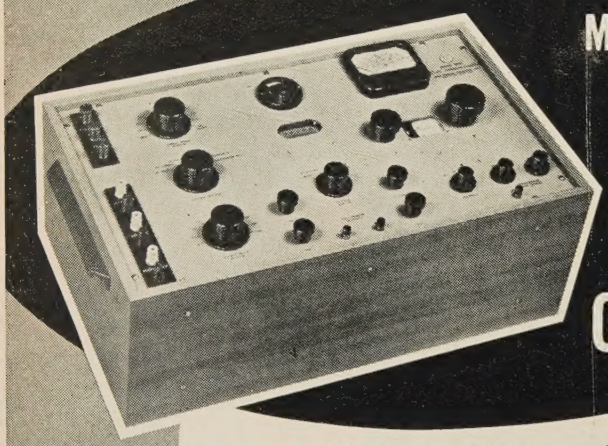
from
Instrument Calibration
HEADQUARTERS

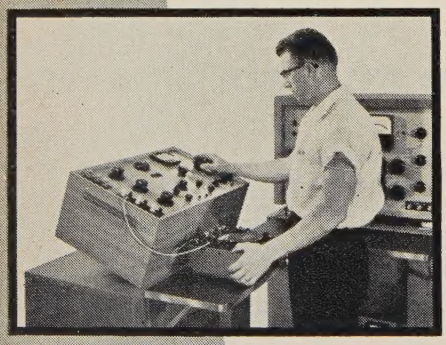


Measures Precise AC-DC Voltage & Current

Model 1605
$2450.

A Self-Contained Laboratory Standard Facility

The Model 1605 AC-DC Calibration/Transfer Standard is a multi-function instrument capable of measuring AC and DC voltage and current up to 1500 volts and 15 amperes. It includes a precision four-digit readout potentiometer, laboratory standard cell, precision voltage multipliers, precision shunts hermetically sealed in oil, light beam galvanometer, AC monitoring meter, thermal converter and all necessary batteries and controls. DC measurements utilize the potentiometer or the potentiometer in conjunction with the voltage multipliers or shunts. For AC measurements the potentiometer and/or multiplier-shunt arrangement is used with the compensated AC-DC transfer element.



LIMIT OF ERROR

DC: 0.05% with correction factors; 0.1% direct reading.

AC: 0.065% with correction factors; 0.13% direct reading.
(AC accuracies are to 50 kc on most ranges.)

For Owners of the RFL Model 829 AC-DC Instrument Calibration Standard

The Model 1605 may be used in conjunction with the Model 829 to calibrate instruments having greater accuracy requirements than that supplied by the Model 829 alone. The Model 1605 may also be used to calibrate the Model 829. The 829/1605 combination provides a calibration system which will handle your requirements, for current and voltage measurements to an accuracy of better than 0.1%, from DC to 400 cps.

Performance is rigidly guaranteed. Price is net, f.o.b. Boonton, N.J. and subject to change without notice.

SEND FOR TECH. DATA

For additional information, including application data, write or phone DE 4-3100. Demonstrations available by local representatives.

RFL Radio Frequency LABORATORIES, INC.
Boonton, New Jersey, U.S.A.

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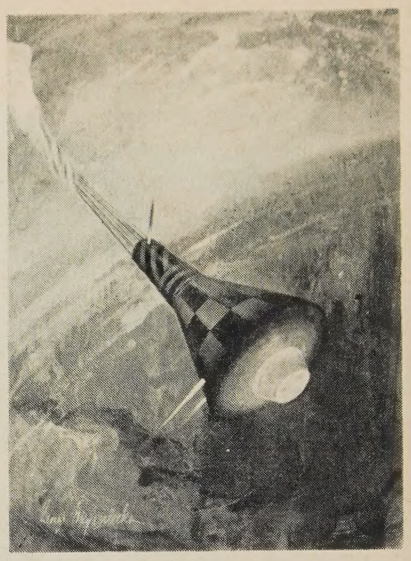
cover story



Re-entry heating, the area covered in this month's technical lead article (page 43) is symbolized on our cover by artist George Meyerriecks' conception of a manned space vehicle descending through the atmosphere. In this case, a metal heat sink shield is used to protect the craft from high temperatures. The bulge in the middle of the shield houses retro-rockets, which have already been fired. The rockets still firing are used for attitude control. The final descent of the vehicle will be by parachute, which can be seen opening up.

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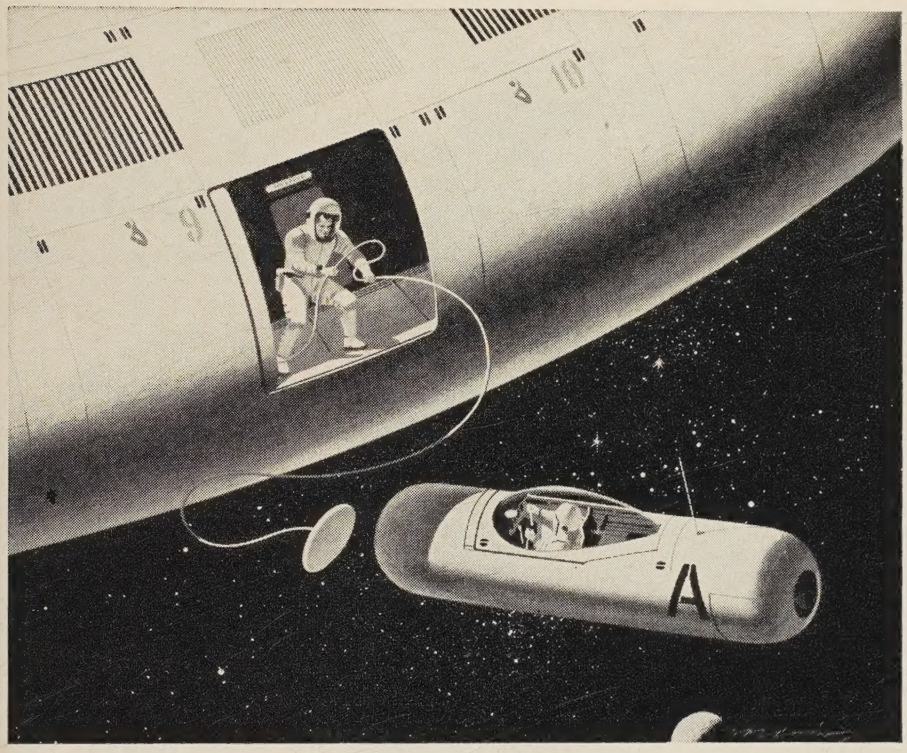
for the conquest of space



WHAT KIND OF ENGINE FOR A SPACE-TAXI?

It takes a unique engine to jockey a space-taxi in for a landing on an orbiting space station—one that will give a space pilot instant control and precise maneuverability.

Such an engine is the fully controllable rocket engine—ideal for space travel yet as easy to operate as an automobile engine.

The rocket engines are ready now

Although the space-taxi is still a gleam in an engineer's eye, the controllable rocket engine is available now...and has immediate application for existing aircraft. The pilot of a plane with auxiliary rocket power can switch it on for sudden, swift acceleration at high altitudes . . . the aircraft's air-breathing turbojets supplying power for ordinary flight operations. This is the mixed-power theory. Since World War II several mixed-power concepts have been developed in foreign countries, including Russia, France and England.

Extra power for today's aircraft

Rocketdyne already has designed, tested, and manufactured rocket engines for mixed power applications. The AR-1 rocket engine is a liquid-propellant system, as are the large power plants for the Atlas, Thor, Jupiter, and Redstone ballistic missiles. The AR-1 passed stringent flight tests as a supplementary power plant on modern jet aircraft. Substantial improvements over normal near-sonic speed and 50,000-foot altitude capabilities were demonstrated in more than 100 test flights.

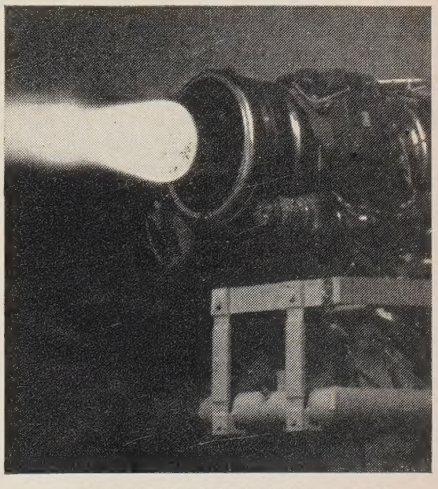
The AR-2, second in a series of four rocket-engine models developed by Rocketdyne, is a fully-throttleable engine that provides varied thrust. Using fuel from the airplane's tanks—which automatically ignites with hydrogen peroxide—these engines have full stop and restart capability.

More value for taxpayers' money

The auxiliary rocket engine gives present aircraft superperformance capabilities at a relatively low cost. It provides the increased speed and maneuverability that could spell the difference between the success or failure of an intercept mission. Almost any existing jet aircraft, as well as those now on the drawing board, can be adapted readily for AR engines.

Looking forward to tomorrow

Beyond a doubt, rocket power has a leading role in the Free World's future. Rocket-propelled airplanes, such as the X-15, will pave the way for man's entry into Outer Space. The multi-million-pound-thrust systems that are now under development at Rocketdyne will be man's means to explore interplanetary Space. But meanwhile, these rapid advances in rocketry can add great strength to America's present deterrent arsenal.



THE MEASURE OF ROCKET POWER

The liquid-propellant AR rocket engines are "static tested" at Rocketdyne's field laboratory to measure thrust and performance.

FIRST WITH POWER FOR OUTER SPACE

ROCKETDYNE

A DIVISION OF NORTH AMERICAN AVIATION, INC.

September 1959

volume 32, number 3

space/aeronautics

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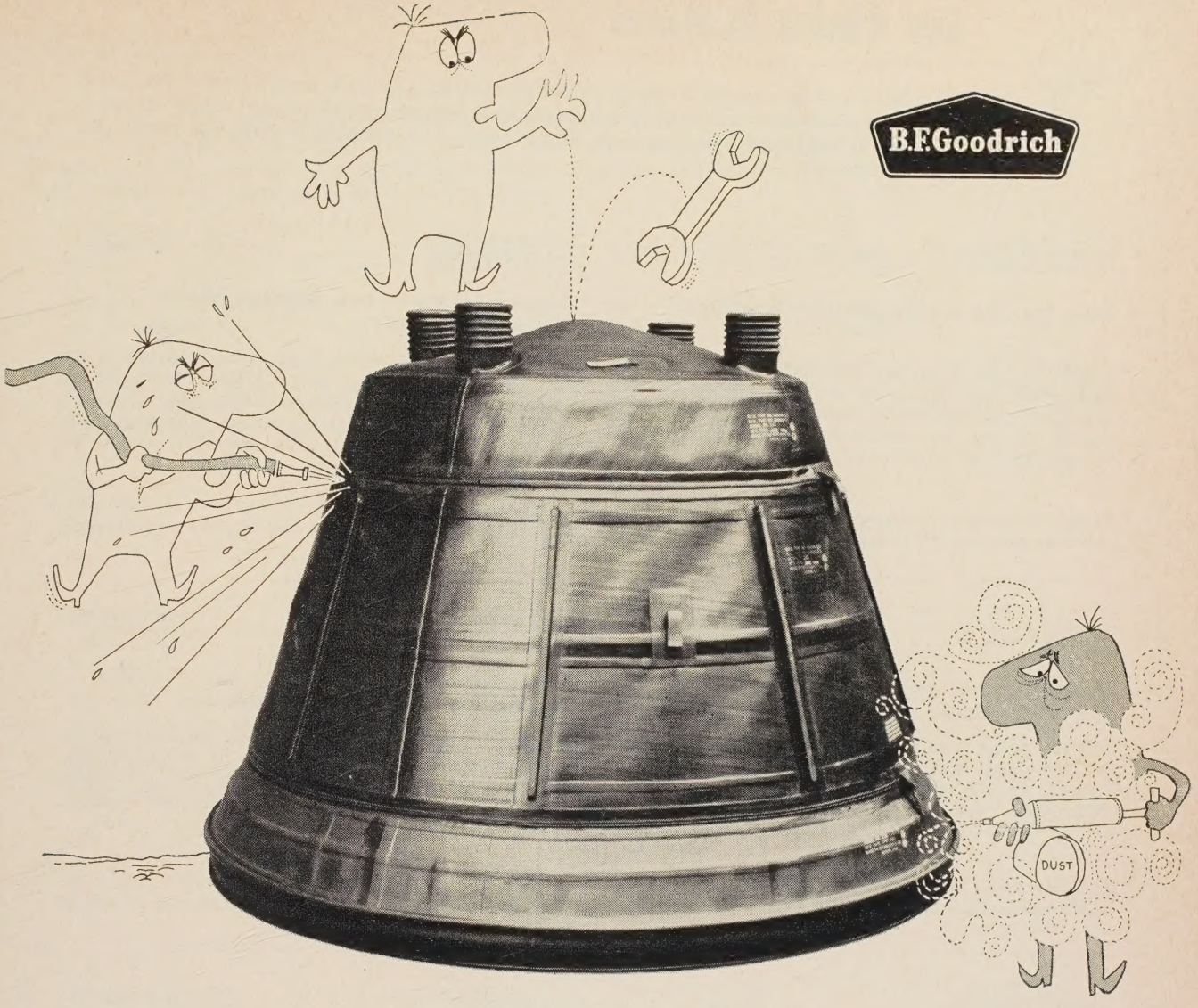


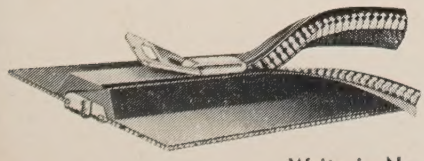
Zippered nose cone cover foils moisture, dust, abrasion

To protect the polished finish of missile nose cones from assembly to countdown, B. F. Goodrich fabricated unique zippered "all-weather" Nose Cone Covers for Avco's Research and Advanced Development Division.

Made from neoprene coated nylon fabric, this shipping cover has non-rigid neoprene ribs and spacers that keep it from riding down on the cone. Special B. F. Goodrich Pressure Sealing Zippers provide easy access and removal—yet seal positively against dust, dirt, grime, damaging impact.

B. F. Goodrich was asked to engineer this special project because of its widely-known ability to manufacture coated fabrics to any shape or size—as in aircraft baggage panels. In addition, the space-saving B. F. Goodrich Zipper—used widely for air ducts, inspection ports, access doors, and aileron gap seals—withstands any pressure up to the maximum strength of the zipper itself. And it, too, can be fitted to complex contours.

Tricky sealing problems like this one are just part of the day's work at B. F. Goodrich. Next time you have such a problem and need an answer—fast—write or call *B. F. Goodrich Aviation Products, a division of The B. F. Goodrich Company, Dept. SA-99, Akron, Ohio.*



B.F.Goodrich ***aviation products***

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in this issue

Here's a quick rundown of the technical information offered in the articles in this issue. You can also use these article abstracts to build up your own permanent record for reference in the future—just clip them, paste them up on standard three-by-five cards, and file them.

Aerospace Engineering
Structures, Materials

Astia code: 2-1; 12-1; 14; 17-2, -4
Your code:

How far are we on re-entry cooling?

Review of state of the art in re-entry cooling. Ablation, sublimation, heat sinks, heats of fusion and solution, and regenerative cooling are discussed. Basic elements of each cooling process are explained, and the suitability of various materials is discussed.

by Kurt R. Stehling, Contributing Technical Editor
space/aeronautics 32/3 (Sep. '59) p. 43

Aerospace Engineering
Systems Engineering,
Structures, Materials

Astia code: 1-2
Your code:

Argosy features two loading doors (Design Progress)

New Armstrong Whitworth Argosy Freightercoach turboprop transport has fore and aft loading doors. Details of door hinging, pallet loading system roller conveyors in floor, floor structure, center section wing attachment to fuselage, and roller bearing assemblies supporting flight control tubes are given.

by Randolph Hawthorne, Editor
space/aeronautics 32/3 (Sep. '59) p. 59

Aerospace Engineering
Accessory Systems

Astia code: 12; 26-8
Your code:

Designing hot-gas servos for long missile flights

Reviews design solutions based on two-, three-, and five-position servos operating off solid propellant grains for up to 10 minutes. Shows schematics of control valves and sketch of a typical package design.

by Charles Delson, General Electric
space/aeronautics 32/3 (Sep. '59) p. 46

Aerospace Engineering
Accessory Systems

Astia code: 2-1
Your code:

Solar and nuclear APUs coming up for space missions

Review of environmenal control and secondary power requirements of space missions and of design possibilities for meeting them. APU applications of gas turbines, batteries, fuel cells, solar cells, thermopiles, nuclear, monopropellant and bipropellant units are covered.

by W. L. Burriss, AiResearch Mfg.
space/aeronautics 32/3 (Sep. '59) p. 63

Aerospace Engineering
Dynamics

Astia code: 1-2; 12-1
Your code:

Power-spectral analysis gives better gust loads data

Discussion of applications of statistical concepts to the problem of gust-load determination. "Transfer-function" and "direct" methods for finding turbulence spectra are described. Data from these methods are compared for specific cases with that from the "discrete-gust" method.

by T. A. Siliciano & W. J. Oakes, Jr., Northrop
space/aeronautics 32/3 (Sep. '59) p. 49

Aerospace Engineering
Production Engineering

Astia code: 26-1
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Advanced welding requires accurate fixturing

Brief state-of-the-art discussion of purrent welding methods in the aerospace industry. Examples of several advanced types of welding fixtures for Heliarc and resistance welding are given.

by W. P. McGregor, Convair-Astronautics
space/aeronautics 32/3 (Sep. '59) p. 81

Aerospace Engineering
Accessory Systems

Astia code: 1-2; 12; 26-6
Your code:

Fast R&D pace set for mechanical constant-speed drives

Design analysis of Lycoming CSD, with sketches and diagrams showing principles of operation. Reviews R&D progress made to date, describes plans for advanced systems applications. Details on mechanical frequency control and electric trim control.

by Victor de Biasi, Associate Editor
space/aeronautics 32/3 (Sep. '59) p. 54

Aerospace Engineering
Accessory Systems

Astia code: 1-2; 12; 25-4
Your code:

Simple periscope protects pilots from nuclear flashes

Description of a rapid-closure optical viewing device to protect crews from sudden flashes of high intensity light. Operational models can have closure capabilities of better than 500 usec.

by Ralph Wight, Fecker
space/aeronautics 32/3 (Sep. '59) p. 89

To make filing easier, each abstract is coded according to the Astia Distribution Guide. Copies of this guide are available from Armed Services Technical Information Agency, Arlington Hall Sta., Arlington 12, Va. There is also room on the abstracts for you to insert your own key if you use a special coding system.

Aerospace Engineering
Propulsion

Astia code: 27-2
Your code:

French push Atar jets up to Mach 3

Design analysis of Snecma Atar 8 and Atar 9 Mach 2 turbojets. Performance data are shown in tables and graphs; a cross-sectional view of the Atar 8 is included. Brief description and sketch of Mach 3 Super Atar.

by Robert Roux, French Corresponding Editor
space/aeronautics 32/3 (Sep. '59) **p. 97**

Aerospace Engineering
Accessory Components, Ground Support

Astia code: 1-2, -4
Your code:

New jet fuel filter-separators feature automatic cutoff

Discussion of fuel contaminant problem, new designs of fuel filter-water separators and their operation. Some typical new units are described, with emphasis on their automatic cutoff features.

by Walter Kasten, Bendix Filter
space/aeronautics 32/3 (Sep. '59) **p. 137**

Aerospace Engineering
Accessory Systems & Components, Propulsion, Testing

Astia code: 12
Your code:

Amplified probes measure Jupiter's LOX temperature

Various possible types of liquid oxygen in-flight temperature measuring systems are discussed. Reasons are given for selection of amplified probe system for Redstone and Jupiter flights.

by C. T. N. Paludan, ABMA
space/aeronautics 32/3 (Sep. '59) **p. 107**

Aerospace Electronics

Astia code: 1-4; 12-2; 19-3
Your code:

Operational needs speed up automatic landing progress

Survey of state of the art on automatic landing of aircraft. Fundamental problems are explained and localizer and glideslope improvements are treated. Major developmental systems discussed include those of Airborne Instruments Lab, Autonetics, Bell Aircraft, British Blind Landing Unit, Cubic, Gilfillan, Minneapolis-Honeywell, and Sperry.

by James Holahan, Electronics Editor
space/aeronautics 32/3 (Sep. '59) **p. 150**

Aerospace Engineering
Accessory Components

Astia code: 1-2; 12
Your code:

Multi-flapper check valve cuts weight, ups performance

Design principles of multi-flapper check valves and analysis of relation between dynamic loading and valve segment shape. Data are given on pressure drops and leakage rate for units of various sizes.

by Arnold Cowan, Bobrick Mfg.
space/aeronautics 32/3 (Sep. '59) **p. 121**

Aerospace Electronics

Astia code: 19-3
Your code:

Drone control system keeps tight formations (Design Digest)

Design analysis of a multi-drone formation control system operating on X-band. Overall functional diagram shows principle of operation. Drawings show location of units in lead and slave aircraft and define limits of angular control. Detail photographs of major units.

by Bernard Kovit, Associate Electronics Editor
space/aeronautics 32/3 (Sep. '59) **p. 157**

Aerospace Engineering
Aerodynamics, Structures

Astia code: 1-2
Your code:

Jetliner wing features "push-button" lateral control

Description of wing control surface system of Convair 880 and 600 jet airliners. Details of linkages and mixer assembly used to interconnect aileron and spoiler-speedbrake systems are given.

by Hugh R. Smith, Convair-San Diego
space/aeronautics 32/3 (Sep. '59) **p. 127**

Aerospace Electronics

Astia code: 8-3; 9
Your code:

Electrokinetic effects in fluids studied by electronics researchers

Discussion of fundamental theory of electrokinetic phenomena in fluids. Diffuse double layer, zeta potential, streaming potential, and electro-osmosis are covered in detail. Electrophoresis and the Dorn effect are defined. Thirty-four equations are given.

by P. M. La Hue, Minneapolis-Honeywell Regulator
space/aeronautics 32/3 (Sep. '59) **p. 161**

continued on page 13

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Photo of Atlas missile courtesy CONVAIR ASTRONAUTICS, A Division of General Dynamics Corp.

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in this issue continued from page 11

Aerospace Electronics
Pages from an Engineer's Notebook

Astia code: 8
Your code:

Finding height from radar shadows (nomograph)

Knowing the heights of hills and similar features on radar maps is important in locating sectors on conventional maps. This nomograph uses the "radar shadow" characteristic for easy determination of height. It is based on the fact that shadow length is a function of object range and height and of the altitude of the mapping aircraft.

by Donald Moffat, Motorola
space/aeronautics 32/3 (Sep. '59) **p. 167**

Aerospace Electronics

Astia code: 8-2
Your code:

How bad is the shock and vibration flight environment?

Description and definition of shock and vibration environments in Navy aircraft and non-ballistic missiles. Frequency bands and average forces in each band are given for structural and engine-produced vibrations. Details are included on the effects of gunfire, carrier landings, catapults and missile launches.

by David D. Blair, Robinson Technical Products
space/aeronautics 32/3 (Sep. '59) **p. 169**

coming next month

GROUND SUPPORT ENGINEERING will be the subject of SPACE/AERONAUTICS' next special report. This report will contain an overall survey of the management problems and engineering trends in ground support, discussions of the interrelationship of vehicle and GSE design and of mobile launch techniques, a Design Progress on the GSE for one of our current ballistic missiles, analyses of checkout equipment as part of the electronic GSE coverage, and listings of GSE projects by weapon system and of company capabilities in the GSE field, as well as a number of other features designed to give you a comprehensive and yet detailed understanding of what's going on in GSE.

THE QUESTION of the best APU for high performance vehicles is still far from settled. Recent experience—which will be analyzed in a major article—indicates that batteries might yet outstrip all the "exotic" APUs about which we've been hearing such rosy predictions.

coming soon

YET ANOTHER SPACE/AERONAUTICS special report is in the making—on Production and Materials Engineering. It will offer you a survey on the design and use of advanced machine tools, bring you up to date on the latest machining, joining, and forming methods, and take up the problems of electronic and automated production. In addition it will contain state-of-the-art reports on the materials field.

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What our editors are doing

WE ARE adding another full-time editor to our staff this month. Based in England, he will keep our readers in close touch with important technical developments in the aerospace industries of Britain and the Continent.

An engineer, with a B. S. from Cambridge, who served with the Royal Navy as an engineering officer, Christopher Dawson was named European Editor by Randolph Hawthorne, S/A's Editor. Details of the appointment were arranged by our Editor and Mr. Dawson during the Paris Air Show last June.

Mr. Dawson comes to us from the British technical monthly, AIRCRAFT ENGINEERING, where he had been deputy editor. He also had been a director of Bunhill Publications Ltd., the magazine's publishing firm.

Our new European Editor will regularly visit the many important firms and R&D centers in Britain and Northern Ireland. Speaking fluent technical French, Mr. Dawson also will penetrate the French aerospace industry and other Continental technical centers where so many important developments are taking place.

He will cover not only trends and design of structures, components, accessories, systems, instruments, test and production of vehicles and powerplants, but will also report development and trends in the electronics field, with which he is familiar.

Speaking of electronics, our Electronics Editor, Jim Holahan, gave a paper on "A Survey of Automatic Landing System for Fixed Wing Aircraft" before the IRE's Western Electronic Show & Convention last month at San Francisco's Cow Palace.

New twist in editor's role

Jim—who, when he attends this important electronics convention, usually asks the questions about the technical developments in the field—put a new twist on his role this year. This time he answered questions put to him by his interested audience of electronic specialists.

If you didn't make it to the Wescon Show this year, you can still find out quite easily what Jim said in his paper: Turn to the Aero/Space Electronics section of this issue and read its lead article (on page 150), which is based on Jim's paper.

Meanwhile, our Astronautic & Propulsion Editor, Kurt Stehling, was on his way to Britain as we write this as a delegate to the 10th Annual Congress of the International Astronautical Federation, now being held in London. He will make a report on the outstanding papers given at the IAF meeting for a subsequent issue.

Kurt, well-known in rocket circles for his part in the Vanguard project and now working in our fast-growing space agency, NASA, was active on the American Rocket Society's program committee.

While in England, Kurt will visit British research establishments. Then he will go to the Continent, where he will see Prof. Eugen Saenger, famous German rocket and space vehicle specialist.

The two project leaders of our special reports coming in October and November are out in the field gathering material for the Ground Support Engineering and the Production & Materials Engineering reports. From the way these reports are shaping up, the reader can look forward to some very useful information.

Vic de Biasi, GSE project leader, has listed some of the subjects the editors are planning to cover in October: (1) Tactical GSE Needs, based on government agency interviews; (2) Interaction of Vehicle and GSE Design; (3) GSE Electronics; (4) Industry GSE Capabilities.

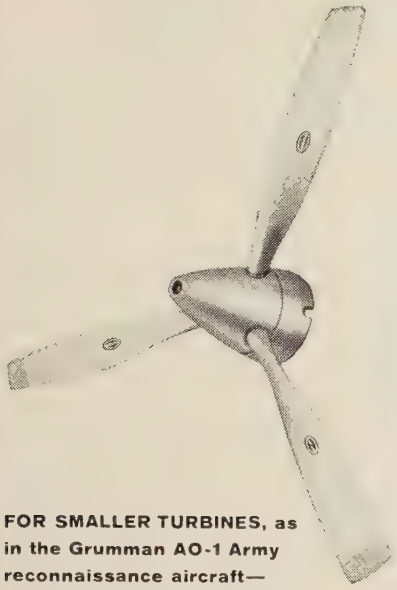
Project leader Irwin Stambler will include a production state-of-the-art article in the Production & Materials report in November. In addition, articles are scheduled on (1) forming methods, (2) machine tools, (3) chipless machining, (4) joining processes, (5) electronic production methods, (6) materials properties, etc.

Incidentally, look for more of our distinctive art covers done by our own artist, George Meyerriecks. George has been given the assignment to symbolize the two reports on the October and November issues. This month's cover on manned re-entry also is his work.

Randy Hawthorne, our Editor, whose recent survey on the metric system brought in overwhelming response in favor of installing the metric in place of the English system in industry, has been invited to be a panel member at the Company Member Conference of the American Standards Association meeting in Detroit October 20-22. Subject: "Should American Industry Convert to the Metric System?" He will speak for conversion to metric. His talk will be based on the returns of his survey. It should contribute to settling the issues of this age-old controversy.

William L. Mann

Publisher



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editorial

Should defense industry hire retired officers?

SOMEHOW the hiring of retired service officers by defense contractors has been given an odor by the Hébert subcommittee. Actually there is nothing inherently wrong with the practice.

We can say it more positively: It is an aid to national defense.

The closest possible liaison and understanding must exist between the services and those in the defense contract business. Lack of it could slow our whole defense program. We can ill afford anything that has this effect.

The most statesman-like approaches to the question were made by two Congressmen, Samuel S. Stratton (D., N.Y.) and Paul J. Kilday (D., Texas). Rep. Stratton told the subcommittee "it would be a grave mistake" to assume there is "something inherently wrong with a retired officer going to work for a defense contractor." On the contrary, he said, the practice is "extremely helpful to national defense."

CHARGES flung against retired officers in defense industry work seem to spring from another mistaken idea. This is that defense contracts are awarded by one or two individuals. But the knowledge of specific weapons systems is not carried in the head of any one man. Congressman Stratton pointed out that, "before any contract can be awarded, the decision must pass through many different hands and many different boards."

As retired Lt. Gen. C. S. Irvine said: "If I wanted to make sure my company did not get a contract, I would go see my successor. I know I would not be welcome in his house."

The whole matter, however, can be looked at from another viewpoint. How best can we use the skills and experience of the retired officers? Surely it is better to use their talents than to consign them to the junk heap. This was the tack taken by Congressman Kilday.

THE DUAL OFFICE ACT of 1894, he pointed out, bars most retired officers from government office. The Dual Compensation Act of 1932 bars most others. But there is an unequal application of both laws. Exceptions have been made by clear provisions of statutes. The Court of Claims provides other exceptions. Still more are provided by Congress in private bills permitting named persons to work in named jobs.

Furthermore, laws restricting retired officers in industry are not uniform in their application to the services. There is no bar in certain sevices, and an absolute bar in others. Legislation should make these laws uniform.

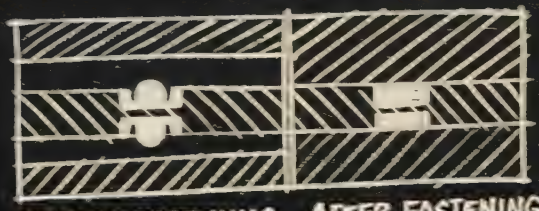
The character of the Hébert inquiry is one of incrimination. It should deal with specific abuses. Instead it smears the retired officers and defense contractors generally. At the same time it does nothing to relax the bar to using retired officer skills in government.

These skills and experience are needed both in government and industry.

Get rid of the disease, by all means; but please don't kill the patient.

Randolph Hawthorne, Editor

LEAKS *CAN* BE STOPPED!



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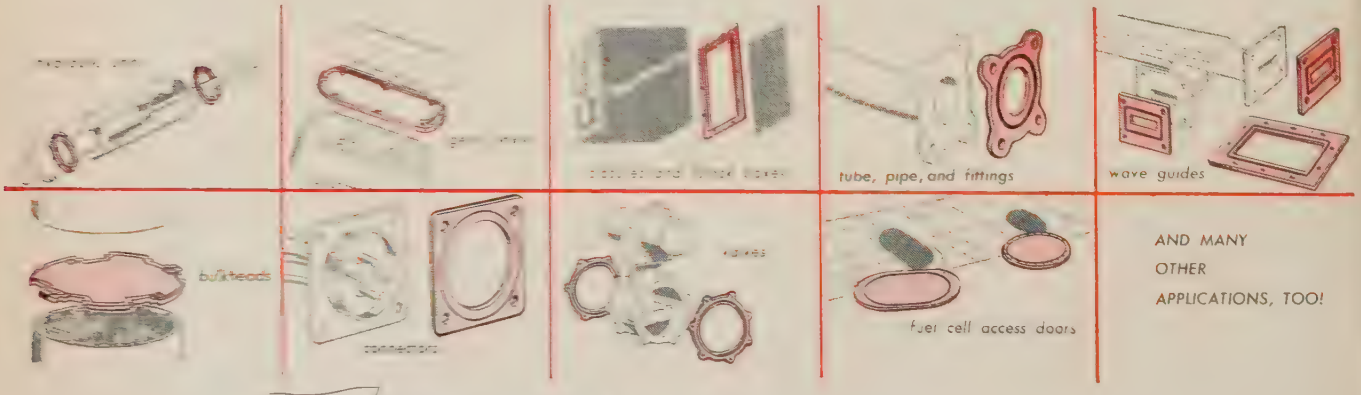

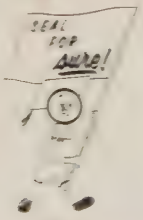

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washington briefing

by A. N. Wecksler, Washington Bureau Chief

AF defends weapon system management

U.S. AIR FORCE is greatly concerned over what it considers a widespread misunderstanding of "weapon system management."

The fallacy is that many consider weapon system management to be the transfer of functions previously carried on by the service to one or several contractors.

In Congress, this misunderstanding has led to questions about placing too much power in the hands of a contractor, overlooking the interests of small business, and an improper abandonment of responsibility by the Air Force.

What the Air Force wants clearly understood is that weapon system management has little to do with how the contracts are let on a given weapon system. It points out that on the B-58, for instance, Convair is the prime and is responsible for the production of everything except the engine and certain smaller items, and that on the B-70 and the F-108, North American is roughly in a similar position.

In contrast, the trend in the ballistic missile field has been toward the "associate contractor system," with one contractor supplying the airframe and responsible for the integration of the system and the testing of the overall weapon, while another supplies the propulsion system, and a third the guidance.

The point that the Air Force is anxious to make is that, in both advanced aircraft and ballistic missiles, the method of contracting in no way changes the basic concept of weapon system management.

Essentially here is the thinking that the Air Force wants to get across: The weapon system management concept is an outgrowth of the change in the nature of weapon production. Prior to World War II, weapons were relatively simple. A high degree of standardization was possible in powerplants instruments, and armament.

As the units became more complex, standardization was difficult. Aircraft became larger and more complex, and this trend took a quantum jump with the ballistic missile.

Lead time from concept to inventory increased. Intricately designed propulsion, navigation, fire control, bombing, and missile guidance subsystems created a new type of problem. These subsystems have to be designed with a knowledge of where in the weapon system they will be placed, as well as a knowledge of what they will be required to do.

As a result, the subsystems became less standard, more completely associated with one specific weapon system.

The weapon system management concept was devised to fit all of the specially designed subsystems into the weapon on a time scale and to key the development and production into the operational phases, training, and finally maintenance.

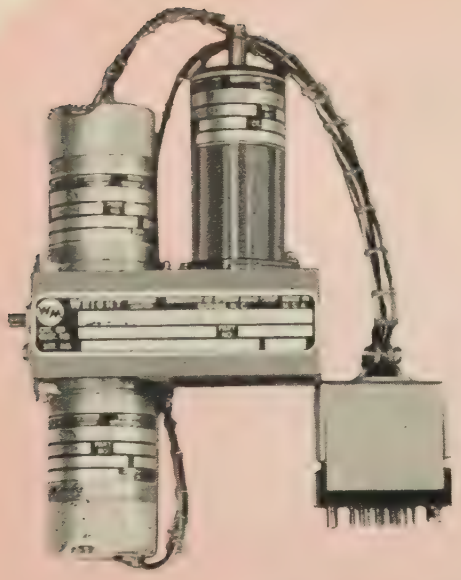
The Air Force organization that does this management job is directed by the chief of staff, who functions as the general manager. Under him is the Air Force Council. A third tier is the Weapons Board, and immediately below are the using functions (SAC, ADC, TAC, etc.). Finally there are the working groups, which have several direct responsibilities for each new weapon:

- phasing the major elements of each new weapon system;
- assessing the capability of current and projected systems;
- monitoring each system from earliest development to the end of its useful life.

The progress and effort of each working group is monitored and coordinated by the Air Force Weapon System Project Office, which ties each project into the work being done on other projects, and also back into AMC, ARDC, and the other USAF commands.

•

A detailed explanation of weapon system management is given in Air Force pamphlet No. 25-2-1, obtainable from Publishing Div., Director of Administrative Services (AFCAS-50), Dept. of the Air Force, Room 1005, Tempo X, 19th & East Capitol St., Washington 25, D.C.



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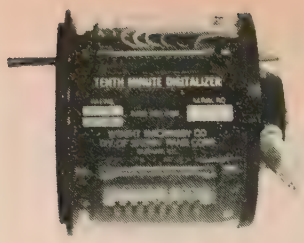

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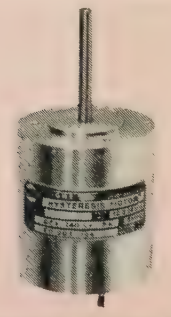

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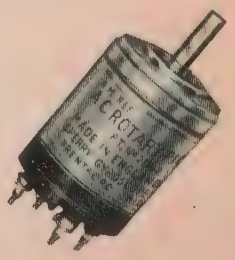

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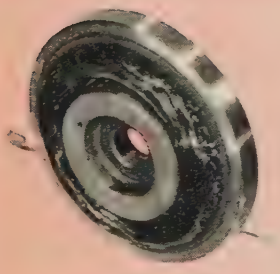

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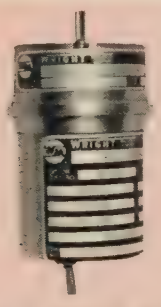

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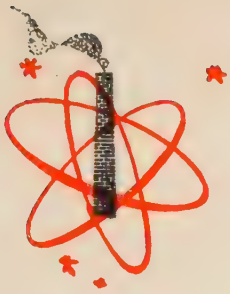


industry viewpoint

by **Robert M. Loebelson,** Associate Editor

Are we wasting brainpower?

DR. WALTER DORNBERGER, vice president, Bell Aircraft Corp.

THE MILITARY services are not making full use of the nation's brainpower as we start to depend more on missiles than aircraft. That's the belief of a man who has probably had longer experience with the weapon system concept than any other.

Dr. Walter Dornberger, who bossed development (under the weapon system idea) of the German V-2 at Peenemünde and is now vice president of Bell Aircraft, finds no fault with the trend toward greater reliance on missiles. "Remember," he says, "that the Russians pretty much chose to bypass long range bombers and concentrate on missiles. Their theory is that if they have enough IRBMs and ICBMs, they don't need bombers. The same thing is happening here. In another five or seven years, we will not be placing much dependence on offensive or defensive aircraft. Missiles are the answer."

But, Dornberger insists, "the move toward missiles and space vehicles requires the use of all the technical brains in the aircraft and electronics industry. The government doesn't seem to be doing that."

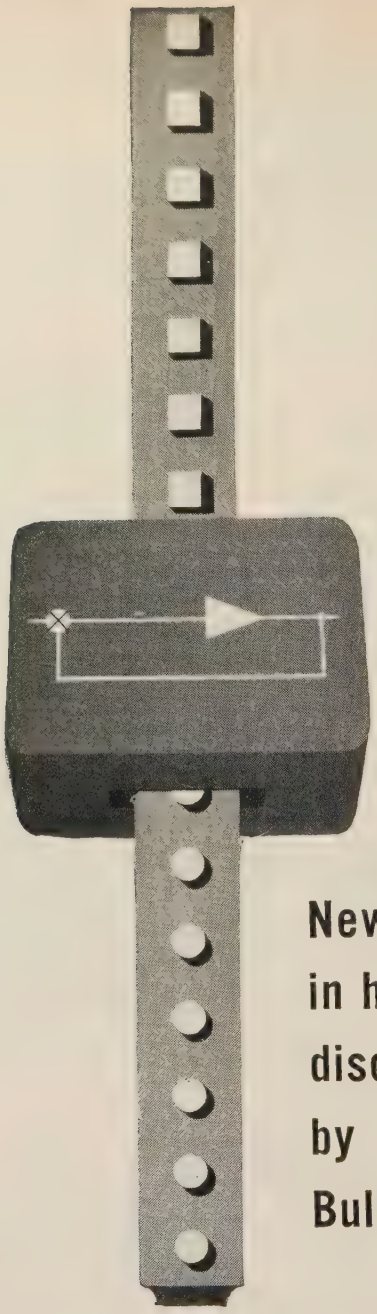
Dornberger maintains that the time is coming when nearly all major missiles and space contracts will be awarded to five or six large firms. "But," he points out, "the nation's brains are not necessarily concentrated on the West Coast."

He points out, "As things stand now," Dornberger notes, "smaller companies spent a lot of their own money to prove a concept. The project is then opened to competition and ends up with one of the bigger organizations."

Dornberger agrees there may be instances in which the military services decide that smaller organizations simply do not have the manpower, production equipment, or managerial know-how to undertake a big project as the prime contractor. "But that still doesn't mean that a smaller company that has proved the feasibility of an idea should be frozen out of the picture. A smaller company should be allowed to participate once it has proved its capabilities," he declares.

Unless this happens, says Dornberger, the small and middle-sized companies will have to get out of the aerospace business, and we'll lose in "progress, ideas, creativeness, and inventiveness. These companies will stop developing if they discover they get no reward for their work. And you must remember that the small firm's lifeblood is the creative engineer. They have continually served as the training ground for engineers who have gone on to work for the bigger aircraft companies. In other words, decisions by smaller companies to stop coming up with new projects may tend to choke off the larger firm's supply of highly qualified and well-trained engineers."

Dornberger is certain in his own mind that the U.S. lost its perspective on space and missile projects after Sputnik I and chose to undertake a complicated program to try to catch up. "The problems won't be solved very easily in any case," he states. "And they certainly won't be overcome if we fail to use the brainpower scattered throughout the industry's big and small companies."



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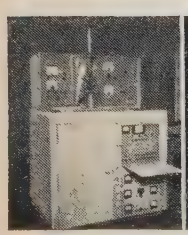
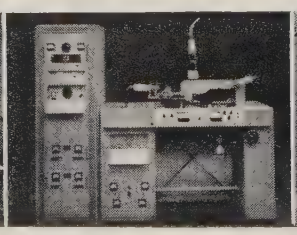

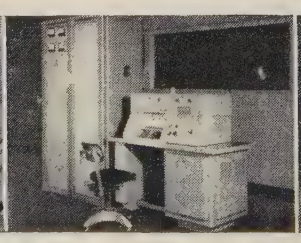

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BULOVA

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TO MEET the demands of many companies that employ more than 500 workers, the government has redefined its small business category for certain types of aircraft and parts. The military services have been allocating certain items as "suitable for small business" for many years. The legal definition was always 500 or fewer employes.

This critical number of workers now has been upped to 1000 for companies turning out airframes and structural components, propellers and hubs, wheel and brake systems, jet engines, fuel tanks, aircraft hydraulic systems, aircraft vacuum systems, aircraft air-conditioning, heating and pressuring equipment, fire control systems, flight instruments, flight simulators (except small cockpit trainers), and aircraft de-icing systems.

The old 500-worker limit will continue to apply to firms that make other types of aircraft equipment.

Work stopped on Mach 2 model of Convair B-58 and its engine

LEAVING existing orders for 66 supersonic B-58 Hustler bombers untouched, USAF scuttled plans for an advanced version of the Mach 2 plane. Convair is being told to stop work on the later model. GE-Evendale is getting the same word on the J79-9 engine. The present B-58 uses four J79-5 engines.

In fiscal '59, AF spent $17.6 million on the advanced Hustler and $19.5 million on the J79-9.

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LOCKHEED-MARIETTA and Sperry Gyroscope have developed prototype QB-47 drone bombers that will be used to photograph flights of the Boeing Bomarc interceptor missile. Two QB-47s are now flying at Eglin AFB, Fla. The drones are fitted with cameras mounted in pods under the wings.

NAVY AWARDED Pratt & Whitney Aircraft's West Palm Beach, Fla., facility a $23.5 million contract to continue development of the J52. The turbojet is programed for the NAA Hound Dog air-to-surface missile and other AF and Navy aircraft and missiles.

FUNDS for the nuclear aircraft propulsion program are split almost evenly between the Atomic Energy Commission and DOD for fiscal '60—AEC will spend $65 million and DOD $75 million for R&D.

BuAer, which has spent $12.4 million on atomic seaplane studies since '55, is programing $2 million more this year and $4-5 million for fiscal '61. It has given Pratt & Whitney Aircraft's, Middletown, Conn., A-engine lab a $2 million contract to fabricate components and develop a secondary heat transfer system for the P&WA indirect-cycle nuclear engine.

Martin got a $127,000 study contract covering airframe designs for an atomic anti-sub warfare seaplane. Martin's Navy studies on such a turboprop go back to '53. Its BuAer contracts during that period have amounted to $1.5 million.

Nuclear aircraft ranked between missiles, new planes

USAF IS PLANNING to continue work on both the GE X-211 direct-cycle and the P&WA indirect-cycle nuclear engines this fiscal year. It will also continue the design analysis of a test bed able to take any nuclear powerplant.

USAF's nuclear program now ranks below new missile projects in priority but higher than any new aircraft programs.

•

OUTPUT of the Boeing 707 is now around 70. Production rate is eight a month, but the Renton, Wash., plant expects to reach nine a month this fall.

KAMAN'S FIRST production HU2K turbine-powered helicopter for the Navy is undergoing tie tests. The second has started a full-scale flight test program. Powerplant is GE's T58 shaft turbine.

The HU2K features the Kaman servo flap and will be capable of all-weather operations.

NAVY'S Airship Early Warning Squadron 1 at Lakehurst, N.J., expects to put the first of four new Goodyear ZPG-3W blimps into operational service in October. The ZPG-3W, which has an envelope with a capacity of 1.5 million cubic feet of helium, will patrol off the East Coast to warn of enemy aircraft. Main detection device is the new APS-70 radar mounted inside the envelope.

AMERICAN AIRLINES has five major specs for the "medium to long-range, all-cargo, turbine-engine aircraft" it is looking for:

• turbofan engines—because current and proposed turboprop cargo planes are "inferior to

more on next page

what can be accomplished with a reasonably developed turbofan engine in speed, lift and economy;"

- payloads in the 40,-50,000- and 80,-100,000-lb ranges for operation from runways no longer than those used by present cargo and passenger aircraft;
- direct flight costs of no more than four cents per ton-mile;
- coast-to-coast nonstop range and cruise near 600 mph;
- mechanized loading system designed as an integral part of the airplane.

MARINE CORPS' Landing Force Development Center, Quantico, Va., began the tactical evaluation of three Gyrodyne YRON-1 one-man "rotocycle" helicopters. The same program on three Hiller XROE-Ls will start in December.

Gyrodyne and Hiller were co-winners of a BuAer competition in '54 to find a simple, light, compact one-man helicopter. The YRON-1 uses a 62-hp Porsche engine to cruise at 50 mph and reach a top speed of 72 mph. It weighs 425 lb empty. The XROE-1 uses a 50-hp Nelson engine to attain a cruise of 50 mph and a top speed of 70 mph. It weighs 300 lb empty.

One of Army's four STOL test beds nearly ready for first flight

FAIRCHILD'S M-24, one of four STOL test beds the Army is financing with R&D money, is nearly ready for its first flight. Ground tests are already underway.

The Army-AF-sponsored Bell XV-3 convertiplane has completed more than 32 AF evaluation flights and more than 61 full conversions.

WITH DOUGLAS Aircraft ready to build a DC-9 powered by four P&WA turbofan engines as soon as enough orders are placed, Boeing is thinking of a twin-engine configuration for its proposed Model 727 short range transport. Since Douglas decided on the P&WA turbofan, Allison, Curtiss-Wright, GE, and Rolls-Royce all are hoping to land the Boeing engine contract.

Boeing is also studying the market for an executive jetliner somewhere between a twin Beech and a DC-3 in size. This plane would be competitive with Lockheed's JetStar, NAA's Sabreliner, and McDonnell's 119. It would use either two P&WA JT-12s or four Boeing gas turbines originally developed for use in ground support equipment.

CANADA'S PLAN to build the Lockheed F-104G and its GE J79 turbojet under license to re-equip its NATO squadrons will cost more than $400 million. Airframes will account for 41 per cent and engines 23 per cent of the total cost.

Orenda has already been picked as the J79 licensee. The airframe will be built by either Avro, Canadair, or deHavilland of Canada.

Northrop stepping up its N-156F sales effort

NORTHROP'S T-38 supersonic trainer and N-156F fighter are both on schedule. GE J85s with afterburners, to be used in the production models of both aircraft, are slated for uninterrupted delivery starting this fall.

With the N-156F already flying, Northrop is stepping up its selling campaign to NATO and SEATO nations.

LOCKHEED will do the engineering design and development work on electronic improvements for two WV-2 radar sentry planes under a $5 million Navy contract. It will equip the two Super Connies with more powerful radar, modernized communication and navigation systems, and a semi-automatic processing system. It will also modify the Curtiss-Wright Turbo Compound engines to boost takeoff and altitude cruise power.

Once an exact configuration is chosen, the Navy will probably follow up with sizable modification contracts for the rest of the WV-2 fleet.

New contract for prepackaged liquid engines

REACTION MOTORS will produce $3.5 million worth of Guardian II prepackaged liquid rocket engines for the Navy at Bristol, Pa. It has already completed delivery of the Guardian I, the first prepackaged liquid powerplant used by any of the armed services.

DOUGLAS' A4D SKYHAWK was the launching vehicle when Temco's air-to-surface liquid propellant Corvus was successfully test-fired at the Pacific Missile Range Test Center, Point Mugu, Calif.

more on page 26

CASE HISTORIES

N/D precision ball bearing end play surpasses needs of linear actuator application. Moreover, bearing is lubricated for extended service against severe climatic condition.

Actuator Photo: Courtesy Armament Division, Universal Match Corp., St. Louis, Mo.

Production Ball Bearings Give Low Cost Answer To B-52 Actuator Problem!

CUSTOMER PROBLEM:

Manufacturer experienced rejects in B-52 aileron trim tab actuator inspections because over-all linear motion could not be held to specified limits.

SOLUTION:

To hold linear actuator end play to proper tolerance, the thrust-supporting ball bearing end play had to be held to a maximum .003". N/D Sales Engineer, working with the manufacturer, recommended New Departure *low cost* single row production ball bearings with standard N/D close internal tolerances. Extensive testing proved that these N/D *production* ball bearings surpassed specifications, assuring end play .001" less than allowed limits. Most important, these high precision N/D ball bearings supplied definite cost advantages over the previous bearings used which required costly hand selection. All this, thanks to New Departure's advanced inspection techniques.

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USAF'S UPCOMING Slam missile, on which a competition winner is due to be named soon, will be a supersonic low altitude design. The ramjet engine for Slam will be nuclear.

MARTIN'S LACROSSE, originally developed by Cornell Aeronautical Lab, is becoming operational with the Army and the Marines. Tactical Lacrosses are being delivered to the Army's 5th Missile Battalion at Fort Sill, Okla.

Navy expects to have Polaris installed on atomic sub by next year

DESPITE some recent partial failures on the Lockheed Polaris, the Navy expects the fleet ballistic missile to be ready for mating to the atomic sub *George Washington* late in '60. The first complete Polaris will be test-fired soon. Tests to date have involved components or Polarises with dummy stages.

AEROJET-GENERAL, which recently bought out Rheem Manufacturing's Defense & Technical Products Division, got a $2 million Army award to improve the design, test, and manufacture of two Rheem-developed AN/USD-2 surveillance drones.

ARMY'S low-altitude Hawk surface-to-air missile was reordered from Raytheon to the tune of $161 million. The contract covers $61 million for missiles, $84 million for ground support equipment, and $16 million for engineering services.

The Army plans to call for an additional $127.7 million worth of Hawks in fiscal '60. Its program involves 15 Hawk battalions, of which 13 are to be operational by next June 30. An advanced version of the Hawk is also programed by the Army and Raytheon.

LYCOMING will produce $6 million worth of thrust chambers for Aerojet-General solid rockets to be used on the Lockheed Polaris and the second and third stages of the Boeing Minuteman.

MARTIN-ORLANDO got a $6 million Navy order (on USAF's behalf) on the Bullpup air-to-surface missile. The supplemental award covers spares, launchers, and other support equipment.

ADVANCED TERRIER surface-to-air missiles, now in production at Convair-Pomona, will first be used by the missile frigate USS Dewey. Later on, the missile will also be fired from mobile ground launchers by the Marines.

AEROJET-GENERAL'S Facilities Engineering Division and Sverdrup & Parcel Engineering will start work later this year on a rocket test stand that can handle 6,000,000 lb thrust. The stand will be built at Edwards AFB, Calif.

Plans call for a two-position stand to handle two NASA 1,500,000-lb thrust liquid rockets. Later the stand is to be expanded to a single test bay that will support a cluster of four of these rocket engines fired simultaneously.

ADVANCED VERSION of the Ryan Firebee target drone was ordered by USAF. The new $8.7 million award runs the order total for the Q-2C up to more than $2.25 million in additional Firebee orders.

New group to speed French space research

FRANCE'S counterpart to NASA and several manufacturing firms are creating a new organization to speed research and output of ballistic missiles. Sereb (*S*ociété pour l'*E*tude & la *R*ealization d'*E*ngins *B*alistiques) will have most of its stock controlled by nationalized manufacturers, including Nord Aviation, Snecma, and Sud Aviation. Private French companies will also participate.

ARPA, which already has five classified programs and Discoverer, Notus, and Transit underway, is programing six additional projects for fiscal '60:

- Tribe, a continuing family of advanced military space vehicles;
- Suzano, a project aimed at developing an orbital platform as a base for space missions;
- Defender, a project to demonstrate the feasibility of advanced defenses against offensive vehicles including ballistic missiles and spacecraft;
- Principia, a study project on solid propellants aired at specific impulses 10-20 per cent higher than those of propellants now under development;
- Pontus, a research program on superstrength, radiation-resistant, high temperature-service materials;
- Longsight, a series of studies and systems analyses in missiles and spacecraft designed to uncover projects needed to meet future military requirements.

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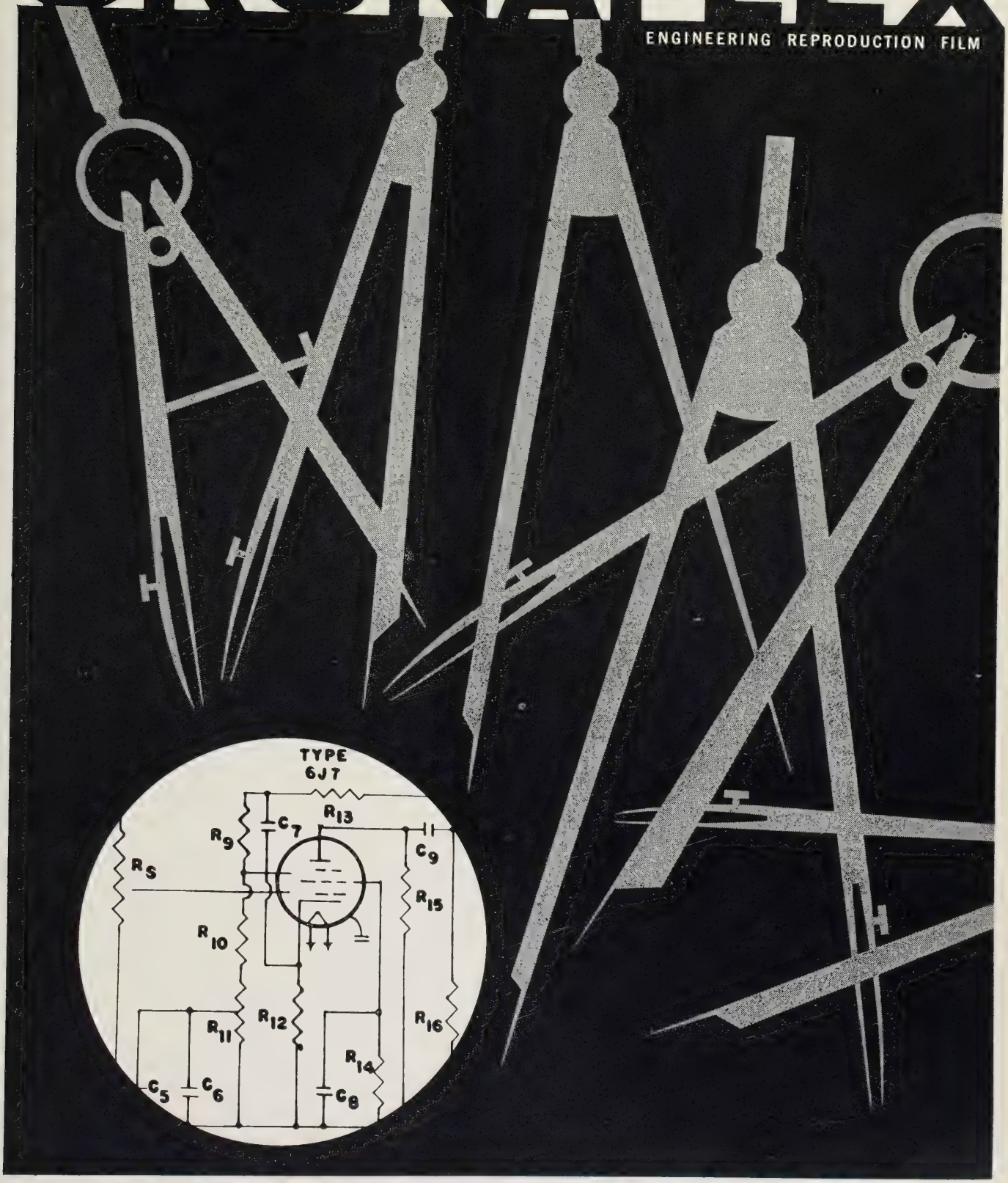

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CONVAIR 880 flight tests, which started on Jan. 27, have shown plane equals or exceeds all original target specs, Convair claims. The 880 can attain 615 mph TAS in level flight with maximum thrust from four GE CJ-805-79 engines according to Convair president J. V. Naish. It has met or exceeded desired operating figures not only over the 3450-mile maximum range but also over shorter medium ranges.

EXPLORER VI launch went off without hitch, sending the 142-lb spherical satellite into an elliptical orbit with an apogee of 23,000 miles, a perigee of 140 miles, a period 11 hours, and an inclination of 50 deg. The Thor-Able III launch vehicle included a 150,000-lb thrust Thor first stage, a liquid propellant second stage; and a third stage using a double-base solid propellant in a glass filament, reinforced-plastic shell.

Explorer VI to collect environmental data and test space propagation

EXPERIMENTS to be performed by Explorer VI fall into two groups:

- space environment data, covering micrometeorite flux and momentum, vector magnetic field, vehicle position determination by means of an STL facsimile system, total radiation flux, cosmic ray count, very low frequency propagation, temperatures, and current voltage data;
- propagation tests, in which two of the payload's transmitters will be used to transmit signals to Hawaii and Boulder, Col.

DOPPLER SHIFT of the two transmitters will be used to set the electron density at the satellite. The rotation of the plane of polarization of the arriving VHF signal at Hawaii will be used to determine the Faraday rotation caused by the change in the ion total along the propagation path to the ground. VHF signals will also be used to measure amplitude and phase fluctuation in ionosphere.

A MAJOR new telemetry system, STL's Telebit, is used in Explorer VI. It is designed to transmit data over interplanetary distances upward of 50 million miles.

A digital unit, Telebit gathers and relays data in a novel fashion. In the past, information had to be relayed as soon as an event—e.g., a micrometeorite collision—occurred. This requirement, state STL researchers, seriously limited telemetry units to single responses and quickly drained the battery. Telebit can collect data and store and tally it while its transmitter is turned off and Explorer VI's nickel-cadmium battery is recharged. When the transmitter is on again, the total data is relayed to the ground.

SOLAR ENERGY converters, mounted on four paddle like arms that sprang into position in orbit, Explorer VI's electric power. The setup consists of 210 modules of 100 silicon solar cells each. The modules have 50 cells per side, producing about ¾ W under direct sunlight.

SHOCK TUBE TESTS simulating entry into planetary atmospheres show the heating rates for Venus might be as much as 50 per cent higher than terrestrial ones, R. W. Rutowski and K. K Chan, of Lockheed's Missiles & Space Div., told the recent Western National Meeting of the American Astronautical Society in Los Angeles. In these tests, a one-inch-diameter hemisphere-cylinder with a heat transfer gage mounted at its stagnation point was placed in shock tube flow to find the stagnation point heat transfer rates in hyper-velocity flow.

Flow durations of about 100 usec were usually obtained. Major components of Venus' atmosphere were estimated as 10 per cent N_2 and 90 per cent CO_2. For Mars, the atmosphere was taken as 95 per cent N_2 and five per cent CO_2. Mixtures of these gases were used to simulate speeds up to 20,000 fps. The tests for Mars entry showed stagnation point heat transfer rates would be only few per cent of those of terrestrial reentry.

Navy finds man is tougher than we'd thought

MAN'S ABILITY to withstand the rigors of space flight seems to be much higher than expected, Rear Adm. J. P. Monroe, Pacific Missile Range commander, told the AAS meeting. In recent Navy tests, he reported, a man was kept under two-g acceleration for 24 hours while performing all normal functions—without any ill effects. Integrated as straight-line flight, said Monroe, this

more on next page

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test would represent a 45,000,000-mile flight in 24 hours.

In another test, a man was held at 31-g acceleration for five seconds in a capsule immersed in water. All previous high-g tests of this kind had been only shock tests, Monroe emphasized.

EXPLANATION of the gravitational field as an averaged fluctuating electromagnetic field generated by the creation and annihilation of charged particles on a subatomic scale was proposed to the meeting AAS by F. E. Alzonfon, of Lockheed's Missiles & Space Div. Such an approach can be considered, he argued, because a given mass may be electrically neutral on a macroscopic scale but won't be so on a subatomic scale.

Alzonfon includes the creation and annihilation processes in physical model by altering the concept of a light signal to cover these processes as fluctuations. "Because the space-time metric is quadratic," Alzonfon stated, "a root-mean-square effect is generated which allows description of matter and radiation by a single field."

Alzonfon gave equations of motion for this field and showed solutions that reduce it to a Coulomb-type field. The force field generated by the creation-annihilation processes is shown to be attractive, proportional to the mass of the source, and inversely proportional to the square of the separation of source and test body.

Alzonfon's model explains the red shift observed in the light from distant galaxies in terms of particle creation rather than of Doppler shift.

Flight trainer combines two control types

NEW FLIGHT TRAINER for manned orbital space vehicles was described to the AAS meeting by W. Kuehnegger, of Martin-Denver. He noted that to date no simulators combine aerodynamic and reaction controls. On centrifuges, he said, only the effects of linear acceleration and deceleration can be reproduced.

The basic unit of the proposed new simulator is a 10-ft diameter sphere pneumatically supported on a contoured base. Incoming air at pressure is discharged through the center of the base only at one end of the sphere. In the static condition, the pressure acting on the spherical surface will be evenly distributed. Kuehnegger stated that only about two psi (at a certain mass flow of air) is needed for initial liftoff. Then the pressure distribution changes over to the dynamic characteristics of mass flow. The air bearing support, Kuehnegger explained, now will only resist the motion of the sphere by skin friction of negligible value.

IN TESTS, the sphere must be completely free of the base to permit unrestrained rotation. The tolerances of the sphere are critical—as they increase, the pressure required in the air bearing increases nearly parabolically. Almost any material could be used for the sphere's shell so long as the stability criteria for buckling produce the required tolerances. The outer base ring, on which the sphere rests, measures 84 in.

The sphere plus a man weigh about 1600 lb. Controls include a stick system for aerodynamic control pitch, roll, and yaw. Twelve reaction jets, mounted flush with the sphere's surface, would be used.

Solar "sail" power supplies prove most efficient in Lockheed studies

SOLAR PHOTOVOLTAIC cells for supplying spacecraft power look promising, J. Douglas Sailor, of Lockheed's Missiles & Space Div., told the AAS meeting. Lockheed studies show a plane configuration of solar cells with its axis perpendicular to the earth-sun axis is most efficient.

This solar "sail" could have a minimum area, Sailor stated, if it were located behind the center of mass of the vehicle, so that the cell array would always face the sun. When the vehicle would be in the earth's shadow or during peak loads, a secondary nickel-cadmium battery would be needed to store power. Such a battery can have nearly 6000 charge, discharge cycles per year, studies show.

SOLAR CELLS should be coated to keep their temperature at a reasonable value, Sailor stated. The maximum temperature of an array near the earth should be between 24 and 60 deg C (depending on the array and the orientation). The coatings under study include silicon monoxide and certain inorganic salt compounds.

Explorer data on micrometeorites show the particle flux in the exosphere is 2×10^{-6} particles per cm/sec, which corresponds to about 60 collisions per cm^2 of solar array per year. Collisions therefore should have little effect on the power output of coated cells, Sailor reported.

more on page 32

59-4

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SOLAR ULTRAVIOLET and primary cosmic rays apparently also would have little effect. Satellite data shows that the Van Allen radiation belt's inner zone seems to consist of electrons with a flux of 10^9 electrons per m^2/sec and protons with a flux of 10^7 protons per m^2/sec. The outer belt consists of electrons with a flux of 10^{10} electrons per m^2/sec. It's believed that protons form only one per cent of the particle flux.

It would take many years before the electron flux could have any noticeable effect on solar cells, said Sailor. However, the proton flux could produce a noticeable loss in power output in only a few months. Until we have more exact data, Sailor stated, satellites using solar power should operate either outside the inner belt or below an altitude of 1000 km.

LUNAR SEISMOGRAPH study contracts were awarded to Columbia UU. and CalTech by NASA. If the current rough schedule works out as planned, NASA states, an attempt to soft-land seismographs on the moon would be made within 5-6 years. The aim would be to study the makeup of the moon's surface activity, the kinds of rocks it contains and whether they're molten, size details, the speeds of meteorites hitting the moon, etc.

Scientists at both universities believe a rugged 10-20 lb device is feasible. It would have retrorockets to soften the landing impact.

"Plug" nozzle's exhaust gases follow contours of a conical spike

PLUG NOZZLE rocket study contract was awarded to General Electric by NASA. In a plug nozzle, the conventional central opening is "spiked," and combustion takes place in a ring of cells about the rocket's base. The idea is that the exhaust gases would follow the contour of the conical spike as they leave the combustion chambers and would push away from it depending on altitude. The movement of gas theoretically would be self-adjusting according to altitude, providing greater efficiency. If successful, NASA states, the study may give data for scaling rocket engines to the multi-million-pound thrust category.

RYAN VERTIFAN got the go-ahead from the Air Force. The design features a fan or set of fans horizontally submerged in the wing and powered by a tip turbine driven by the jet engine exhaust to provide lift for VTO and hovering.

Above and below the fan are moveable vanes to deflect the mass flow from fans. For VTO and hovering, the vanes would be vertical; for forward flight, the upper vanes would slant forward and the lower vanes aft. For landing, the vanes would open, slant forward for deceleration, and then move to vertical as the plane's speed approached zero.

Anti-ballistic Bomarc seen with new ramjets

ADVANCED RAMJETS could give Bomarc extra range, speed, and efficiency, Marquardt's president, Roy E. Marquardt, told a press conference on the firm's fifteenth anniversary. If the go-ahead were given, he stated, these engines could even give Bomarc anti-ballistic missile capability.

Marquardt also reported progress on the development of a nuclear ramjet. The work has progressed so far that now a separate Nuclear System Div. is being set up, he stated. Marquardt noted that Project Slam would use this type of engine if it proceeds. "Nuclear ramjets," said Marquardt, "would allow a missile to fly at supersonic speeds at very low altitudes for essentially unlimited range. With chemical fuels, this hasn't been possible, because it takes so much power for low altitudes, you don't go very far."

MARQUARDT is working with a number of airframe firms on possible uses of ramjets in Mach 3-5 transports. At Mach 4, he states, the ramjet is the most efficient available powerplant of its type. One of its advantages is that it can use boron fuels, which look promising for these flight regimes. In turbojets, Marquardt states, boron fuels form boron oxide particles on turbine blades. There's no such problem with ramjets, which don't need turbines.

Marquardt engineers, their president reports, are working on a new type of ramjet that may overcome the present disadvantage of zero static thrust. Their goal is a perturbation of the ramjet cycle that would lead to designs with enough static thrust to make it possible to use ramjets over the full flight span from takeoff to landing, Marquardt says.

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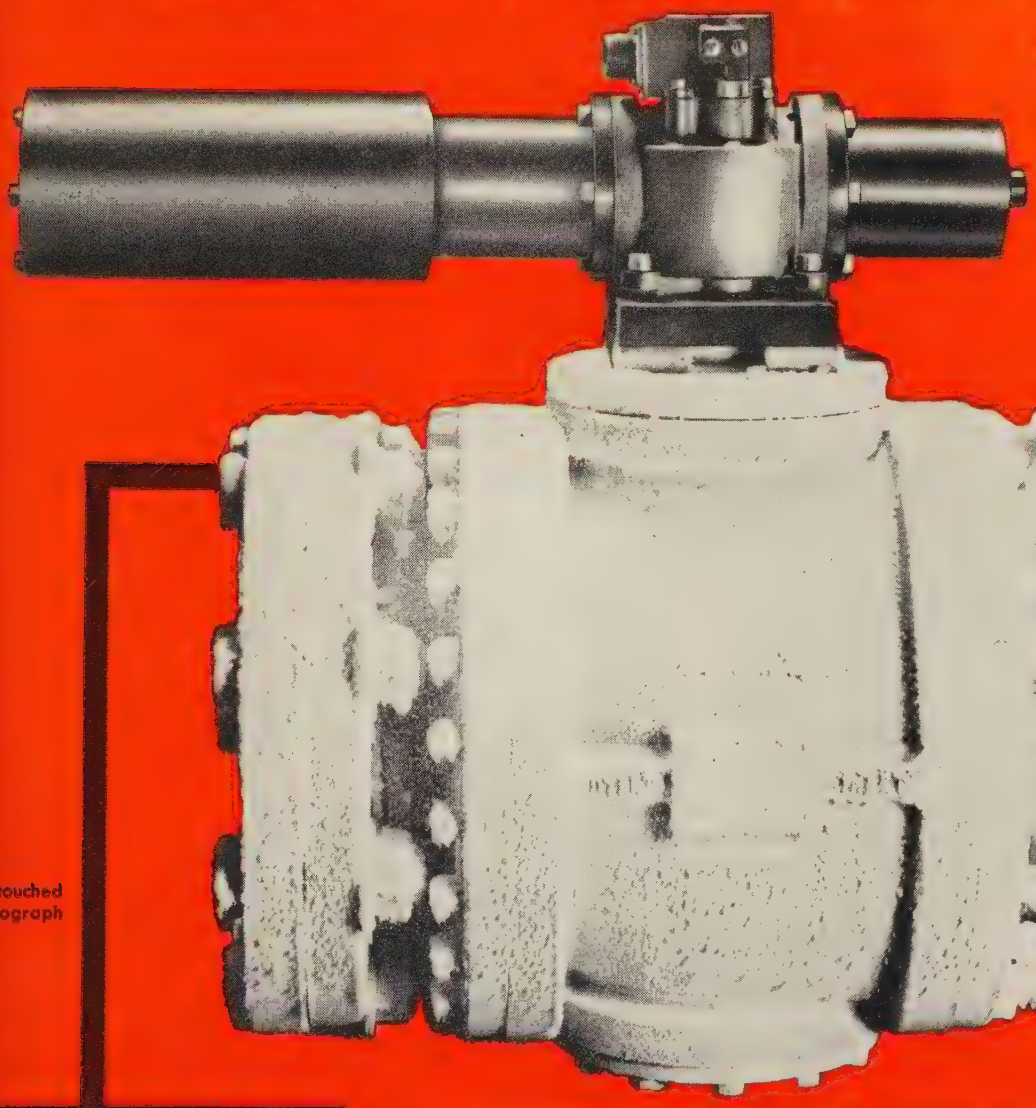
Maximum performance



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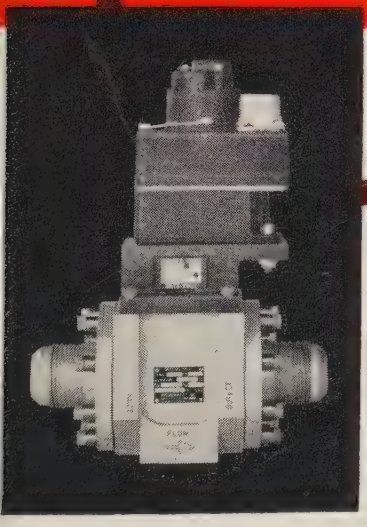

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NUCLEAR SEAPLANE study program at Martin-Baltimore is being stretched out. The Navy awarded Martin a $127,000 R&D contract to study airframe designs for a nuclear antisub turboprop. The contract is part of an overall Navy program aimed at putting a nuclear seaplane in the air by '64.

Too many radiation troubles with direct-cycle nuclear engines

INDIRECT-CYCLE nuclear engine is considered preferable by the Navy because of the radiation problem. The Navy's objections to direct-cycle designs once were summed by Vice Adm. J. T. Hayward, Assistant Chief of Naval Operations for R&D: "We do not believe in a direct air cycle. It has some very fundamental drawbacks to our problem. It has the divided shield instead of the unit shield. It exposes all of our equipment to radiation. We just cannot live with it."

INTEGRATED pilot capsule for aircraft is being developed by Chance Vought under a Navy contract. Initial configuration will be tailored to the F8U-1 Crusader, but the design principles will be applicable to other aircraft, too, and to manned space vehicles.

C-V's capsule design will consist basically of a sealed-off and independently pressurized forward section. It is to enable the pilot to fly in his "shirt sleeves" without any pressure suit, oxygen mask, parachute, etc. For emergency separation, a rocket would boost the capsule away from the rest of the aircraft. Retractable fins would stabilize the capsule and force-sensing drag brakes would decelerate it.

The capsule design project calls for improved instrumentation, air conditioning and pressurization, new restraint system and anti-blackout equipment, better flight controls and soundproofing, pilot seating, and cockpit entry, as well as new survival and communication aids. Thermal radiation shielding will also be added for greater protection on bombing missions.

SEPARATION is the big problem. How do you provide for disconnecting tubing, electric wiring conduits, control stick linkages, etc., without excessive weight penalties? And how do you provide at the same time a sealed environment in the separated capsule?

ADVANCED NOSE CONE for the Titan ICBM is being developed by Avco. The fact that the Air Force set aside $73 million for R&D alone on this project seems to indicate that the subsystems in the new cones will differ appreciably from those in the "old" cones.

A SLENDER nose cone will be developed for faster re-entry. By reducing the re-entry time, the Air Force hopes to cut the chances of enemy detection and interception.

Faster descents into the atmosphere will mean greater instantaneous heat. The advanced Avco nose cone will use ablation to carry off the excessive heat of re-entry.

Red-Eye to be fired by one man from "bazooka"

RED-EYE surface-to-air missile is being developed by Convair-Pomona under a $6 million Army contract for use against strafing and bombing aircraft. Both the missile and its launcher can be carried by one man. The missile is shoulder-fired from a bazooka-like launcher tube, which also serves as a carrying case. The launcher is about four feet long, three inches in diameter, and weighs about 20 lb.

Red-Eye is optically aimed. In flight, an infrared guidance system takes over.

PRECISION GEAR packages are in for drastic miniaturization. According to Edward A. White, president of Bowmar Instrument, Ft. Wayne, Ind., today's ultra-precision units are still crude compared with what will be needed in the immediate future. Bowmar is working on a gearhead less than one inch long that will produce a 6000:1 ratio. Yet within another year of miniaturization, says White, this gearhead will be considered mammoth.

ACOUSTIC thrust control technique has been proposed for solid propellant rocket engines. NASA awarded Acoustica Associates an R&D contract for a study program and feasibility tests with actual solid propellant charges.

The system conceived by Acoustica scientists would control thrust by varying the intensity of sound energy in accordance with a thrust setting. The solid propellant burning rate would be varied by introducing the high intensity sound energy into the combustion chamber during flight.

SELECTION CHART

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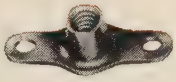
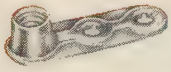
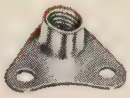
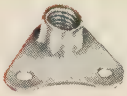
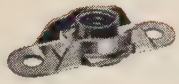
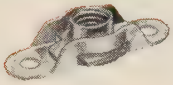
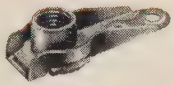
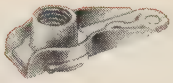
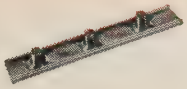
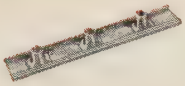
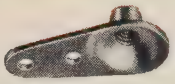
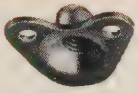
Standard—550° F. (Carbon Steels)	Standard—900° F. (A286 Stainless)	Miniatures—550° F. (Carbon Steels)	Miniatures—900° F. (A286 Stainless)
LHTE (NAS 679)	LHTE2860	LH1660	79LH1660 (303 Stainless)
 LHTA51 (NAS 680)	LHTA51-2860	LHTA51M (NAS 697)	LHTA51M2860
LHTA58 (NAS 681) 100° Ctsk	LHTA58-2860 100° Ctsk	LHTA575M (NAS 1067)	LHTA575M2860
LHTA57 (NAS 682)	 LHTA57-2860	LHTA57M (NAS 696)	LHTA57M2860
 LHTA55 (NAS 684)	 LHTA55-2860	LHTA55M (NAS 698)	LHTA55M2860
 LHTA521 (NAS 686)	 LHTA521-2860	LHTA521M (NAS 1068)	LHTA3300
 LHTA517 (NAS 687)	 LHTA517-2860	LHHA3575	
 LHTG51 (NAS 688-92)	 LHTG51-2860		
 LHTA54 (NAS 683) 100° Ctsk			
 LHTA35 (NAS 685) 100° Ctsk			
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calendar

September 3-6—National Convention & Aerospace Panorama, Air Force Assn., Exhibition Hall, Miami Beach, Fla.

September 6-16—Production Engineering Show & Machine Tool Exposition, Navy Pier, Chicago.

September 7-11—Annual National Technical Conf., Illuminating Engineering Society, Fairmont & Mark Hopkins Hotels, San Francisco, Calif.

September 7-13—1959 Farnborough Flying Display & Exhibition, Society of British Aircraft Constructors, Farnborough, Eng.

September 9-11—Sixth Midwestern Conf. on Fluid & Solid Mechanics, AFOSR Directorate of Aeronautical Sciences, Office of Naval Research, National Science Foundation, Univ. of Texas, Austin, Tex.

September 14-16 — 14th Midwest Quality Control Conf., American Society for Quality Control, Sheraton Hotel, French Lick, Ind.

September 16-17—Western Regional Meeting on Frontiers of Science & Engineering, Institute of the Aeronautical Sciences, Los Angeles, Calif.

September 17-18—Engineering Management Conf., American Society of Mechanical Engineers, Statler-Hilton Hotel, Los Angeles, Calif.

September 18-19—Third Biennial Technical Symposium "Antennas and Propagation," Cedar Rapids Section, Institute of Radio Engineers, Sheraton-Montrose Hotel, Cedar Rapids, Iowa.

September 20-25 — 14th Annual Conf. & Exhibit, Instrument Society of America, Chicago Amphitheater, Chicago, Ill.

September 21-22—Eighth Annual Meeting on Investment in Survival, Standards Engineering Society, Somerset Hotel, Boston, Mass.

September 23-24—Engine & Operations Symposium, Airwork Corp., Millville, N. J.

September 23-24—Engine & Operations Symposium, Airwork Corp., Millville, N. J.

September 24-25—Solid Propellants Conf., American Rocket Society, Princeton Univ., Princeton, N. J.

September 28-30—1959 National Symposium on Telemetering, Civic Auditorium & Whitcomb Hotel, San Francisco, Calif., Professional Group on Space Electronics & Telemetry.

September 30-October 1 — Eighth Annual Industrial Electronics Symposium, IRE, Professional Group on Industrial Electronics, American Institute of Electrical Engineers, Pittsburgh Section, Mellon Institute, Pittsburgh.

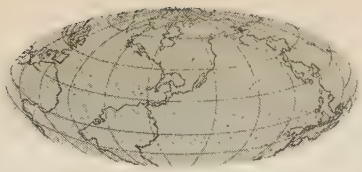
October 5-7—Seventh Anglo-American Aeronautical Conf. Institute of the Aeronautical Sciences, Hotel Astor, N. Y.

October 5-10—National Aeronautic Meeting, Society of Automotive Engineers, Ambassador Hotel, Los Angeles, Calif.

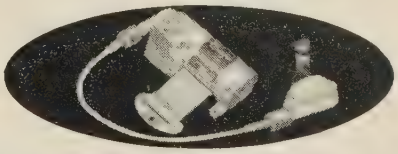
October 6-9—International Symposium on High Temperature Technology, Stanford Research Institute, Asilomar Conf. Grounds, Monterey Peninsula, Calif.

October 8-10—Society of Experimental Test Pilots' Symposium on Pilot's Role in Space Exploration, Beverly Hilton Hotel, Beverly Hills, Calif.

PICTURE CREDITS—Cover, p. 6—S/A; pp. 43-45—NACA, S/A; pp. 46-48—General Electric; pp. 49-53—Norair; pp. 54-57—S/A, Lycoming; pp. 81-84—Convair; pp. 89-94—Fecker; pp. 107-118—USA; pp. 121-124—Bobrick Mfg.; pp. 127-134—Convair; pp. 137-140—Bendix Aviation; pp. 161-164—Minneapolis-Honeywell Regulator.



TODAY ON JET AIRLINERS* THE WIDE WORLD OVER...



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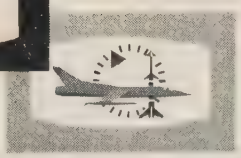

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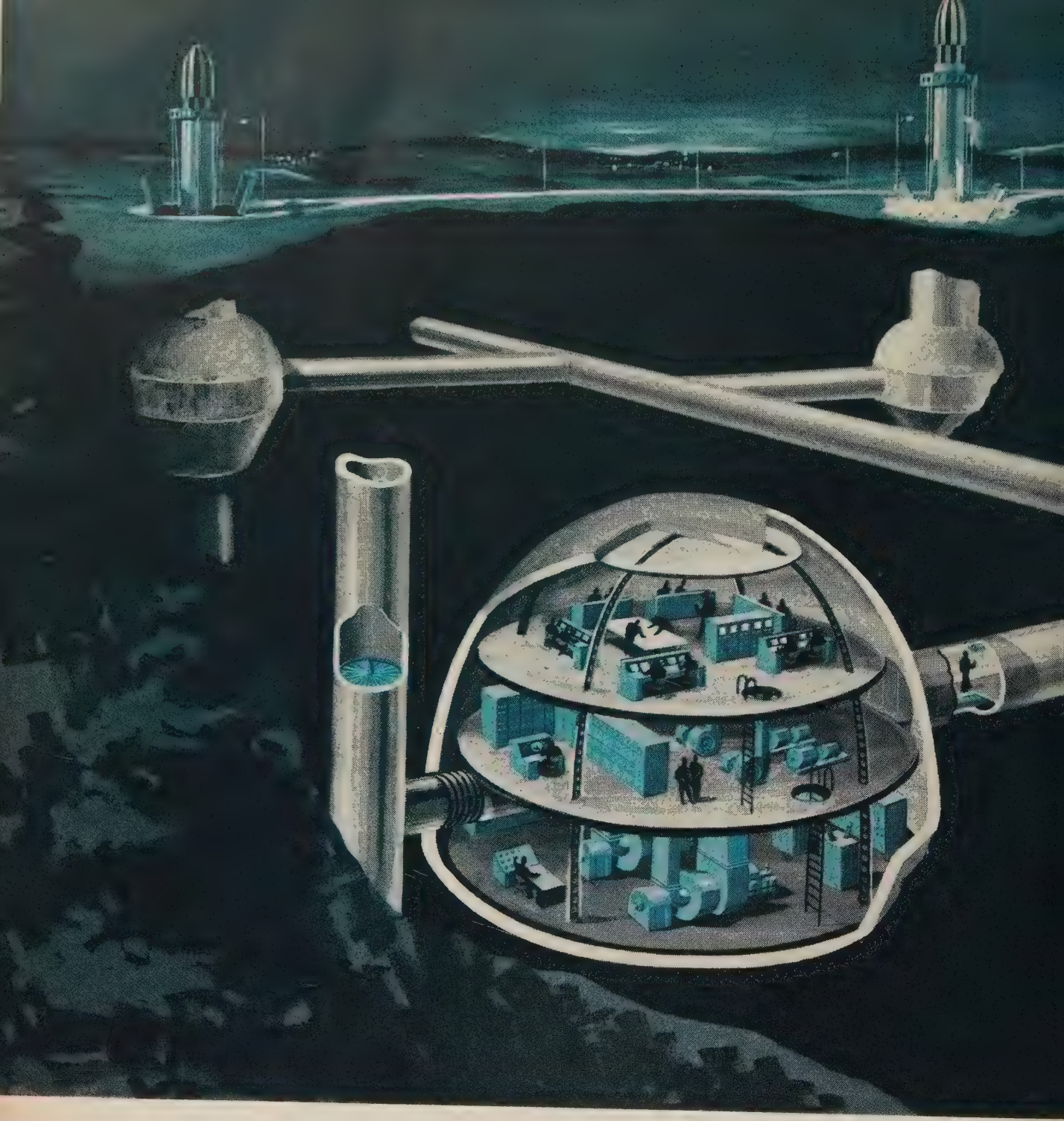

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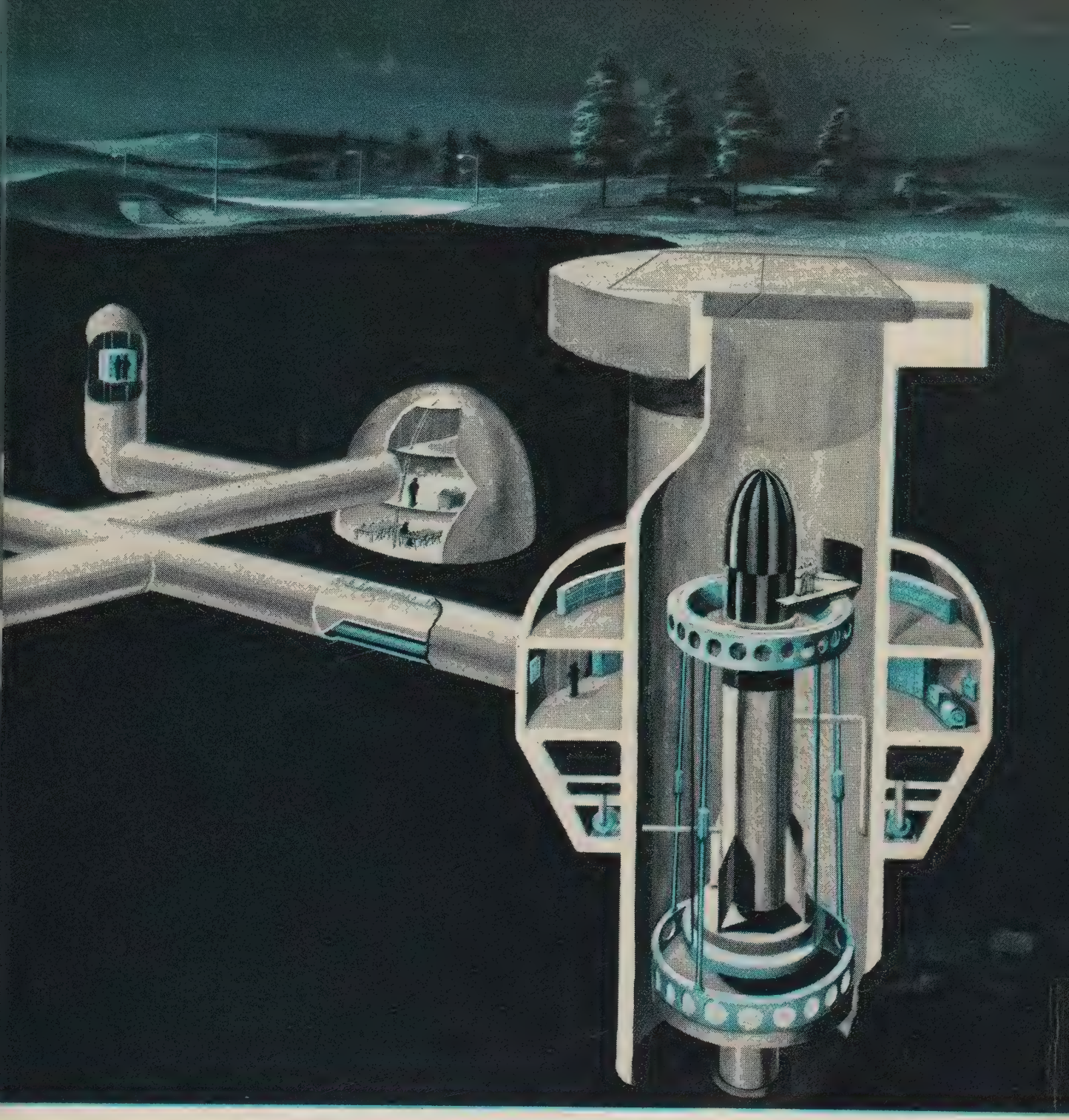

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Big future for technical managers in long range planning

How does an engineer get into technical management? It's all very well and good to say the overall trend is toward an upgrading of engineers who show administrative and executive ability. That alone doesn't tell the ambitious engineer where to look for his opportunities. Here is a report on a specific field of management in which there are plenty of such opportunities—the business of long range forecasting and planning.

by Robert M. Loebelson, Associate Editor

IN COMPANY after company, top management has come to realize that without long range planning there's no surviving in the aerospace industry. Some firms have been building up corps of long range planning experts to forecast military and civil needs and plan projects to meet these needs. Others, which had taken an attitude of "Let's wait and see what the future brings," are in serious danger. Still others, which only hesitatingly got into long range planning several years ago, are beefing up their planning departments to make certain they can continue to produce in the future.

One characteristic is common to virtually all long range planning departments in the aerospace industry—regardless of the size of the company, a group of technical men form the nucleus of the department.

The reason for this pattern is simple enough. In view of the changing technical character of the aerospace industry and the tremendous emphasis on strictly technical problems, most firms are convinced that only a technical man can anticipate the future needs of their customers, both civilian and military, and match them against the company's capabilities.

The military services also appear to regard technical men as the best-qualified crystal-ball gazers in the aerospace industry. They have shown their confidence in the special abilities of scientists and engineers by letting operations research contracts to groups staffed mostly by technical men (see *Box*). The results of these contracts have a large, if not decisive, bearing on the military's approach to basic problems of national defense.

At North American Aviation-Los Angeles, for example, William M. Darling serves as assistant to the vice president for engineering and planning. In this role, he works with a twelve-man long range planning board that is constantly trying to outguess the future and so make certain that North American will be ready for it.

Emphasis on the technical man

Darling explains NAA's attitude this way: "For proper development planning, we decided various types of talents were required. But the greatest emphasis is on the technical man. That's why most of the 12 men on our planning board have technical training."

At Aerojet-General, headed by former Navy Secretary Dan A. Kimball, a corporate advanced planning group backs up the long range planners working in each of the company's divisions. The division planners

(up to five men) try to look five years into the future, while the corporate body makes studies extending well beyond that period.

Says B. L. Dorman, who heads the corporate planning organization: "The people in our planning body are primarily company veterans—engineers, physicists, technical people with military experience, and the like. When we undertake specific studies, we can and do call on the talents of technically qualified people working in the various Aerojet divisions. And we call in consultants, when necessary, to analyze future budgets or market surveys."

"Basically," Dorman adds, "the technical men in our planning organizations are the ones who have to help decide which way Aerojet will go in such areas as space, undersea warfare, anti-missiles, anti-submarine activities, and so on. They are the ones who can really understand the engineering problems and the ways of overcoming them."

Reviews all research projects

Companies making components and accessories have adopted pretty much the same approach. Garrett, for example, has a five-man corporate research board under the chairmanship of Dr. W. T. von der Nuell. The Los Angeles components maker has assigned Dr. von der Nuell's group to "review all Garrett research activity, maintain long range studies of component system requirements in space, direct proportionate emphasis in specific areas, lend assistance in planning and in actual work process, and keep abreast of current requirements for manned and unmanned aircraft."

Dr. von der Nuell, a former director of the Institute for Turbomachinery in Berlin and onetime member of the German Academy of Aeronautical Sciences, agrees that the technically trained man is indispensable in long range planning. He also carries the concept back one step. "Remember," he points out, "that the organization end of long range planning comes into play after a batch of good ideas have been generated within the organization. Most of these good ideas come from engineers and other technically trained people."

Predicts up to 20 years ahead

Lockheed follows a pattern similar to NAA's in long-range planning. Each Lockheed division has an operations research group, made up primarily of technical personnel, which attempts to plan five years into the future. At the corporate level is a 10-man development planning department under Dr. James E. Lipp, which predicts up to 20 years ahead.

Dr. Lipp explains that, while scientific backgrounds predominate in the corporate planning body, "we use every type of individual. We use experts in missiles, military operations, physics, electronics, propulsion, atomic energy, and economics in the planning department." An indication of the level at which Lockheed places the planning department is found in the group to which Dr. Lipp reports: He is responsible directly to

more on next page

From Mechanical Engineer to Long Range Planner

Carlos C. Wood, vice president and director of advanced engineering at Douglas Aircraft, is typical of many technical men in the aerospace industry who are moving into long range planning. In his present job, Wood is responsible for the planning of engineering programs and for forecasting technical trends for the next 5-15 years.

Wood, who has an M.S. in mechanical engineering from CalTech, started out as design consultant for Douglas in 1934. Here are the steps by which his career has carried him from engineering into technical management:

- chief designer, Hughes Aircraft and Aero Engineering (1934-37)
- designer, National Aircraft (1935-37)
- draftsman, Douglas (1937)
- preliminary design engineer, Douglas (1940)
- chief preliminary design engineer, Douglas (1943-1955)
- chief engineer, Douglas-Long Beach (1955-1959)

For engineers and scientists who want to get into long range planning, Wood has this word of advice: "Become well versed in production problems, in budgets and sales, in competitors' activities, and in your own company's capabilities and limitations."

Long Range Planning Contracts

Long range planning by technically trained men is needed by the military as much as by industry. All three services and the Office of the Secretary of Defense have programed operations research contracts with non-profit institutions for fiscal 1960. Many of these contracts cover long range planning and involve scientific personnel. The fiscal 1960 breakdown is:

Service	Contractor	Personnel Involved in Contract	Funding
Army	Operations Research Office, Johns Hopkins U.	469	$ 4,530,000
Navy	Operations Evaluation Group, Massachusetts Institute of Technology	115	$ 1,420,000
USAF	Rand	807	$13,500,000
DOD	Institute for Defense Analysis	347	$ 6,350,000

Lockheed's policy committee, the top four executives of the company. However, his group's findings and recommendations are also funneled to the divisions and subsidiaries to keep these Lockheed units informed of the company's projects and plans.

Planning tied to current work

Some firms prefer to restrict their planning to five years or less. Ryan Aeronautical, for example, makes no effort to go beyond that period. As C. A. Stillwagen, vice president and treasurer, explains it, "Most of our so-called long range planning is tied to our current business because of Ryan's peculiar relationship as a large subcontractor. However, we do a substantial amount of planning in areas where we have prime responsibility like electronics."

According to Stillwagen, Ryan tries to forecast one year ahead every quarter and to project plans for the next five years ahead on a semi-annual basis. Ryan's planning group is made up of the company's top executives, who are primarily men with engineering training.

Special assistant for planning

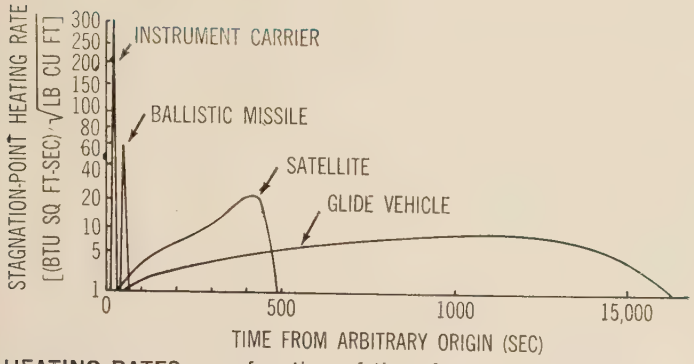
Solar Aircraft has created the post of assistant to the president for long range planning and picked Whitney Collins to fill it. Solar's long range planning council is made up of Collins (who has a technical background), president Herbert Kunzel (an attorney by training), vice president-operations W. G. Dollmeyer (an engineer), the vice president for finance, and the chief engineers of Solar's Des Moines and San Diego facilities.

Convair's approach differs only slightly from the general pattern. Each of Convair's divisions has its own operations analysis group, made up mainly of scientists and engineers. In addition, Elmer Wall, vice president-planning since August 1957, has a four-man corporate group to help him evaluate new business, study commercial products, and make plans for the company's future. Wall uses the operations analysis groups in the divisions to back up his own work when necessary. And to make certain that there are no gaps in Convair planning, vice president-engineering "Sparky" Seybold's office has its own systems evaluation group.

Lab works on products for future

Still another concept is used by Hughes Aircraft. Warren Mathews, vice president-engineering, heads a special committee that determines the firm's course after studying the future trends. But the separately organized Hughes Research & Development Labs can be considered a long range planning group all by itself. Manned overwhelmingly by scientists and engineers, it is concerned with future products, and each working group is trying to meet some anticipated requirement.

The trend in the aerospace industry clearly is toward further expansion of long range planning and the inclusion of various scientific and engineering types to round out the qualifications of each planning group. With each passing month, therefore, the opportunities for the qualified technical man to participate in long range planning continue to grow.—End



HEATING RATES as a function of time for steep and shallow re-entries.

Heats of Fusion

	Melting Point (deg K)	Heat of Fusion per Gram (cal)
Oxygen	54	3.3
Ocetone	178	23.4
Ammonia	196	83.9
Water	273	79.7
Copper	1357	41.8

How far are we on re-entry cooling?

Only a few years ago, the problem of re-entry heating seemed to pose almost insurmountable obstacles. Today we know that this problem is not a particularly tough one.

by Kurt R. Stehling, Contributing Technical Editor

MOST OF our current operational and developmental re-entry designs rely on ablation for heat protection. Taken literally, "ablation" means the "wearing away of a substance" and represents a special case of physical erosion. However, as the term is used in re-entry design, it also covers a second process—sublimation, or the direct change of a solid into the gaseous state (skipping the liquid state). It definitely would not do for the re-entry designer to forget this second aspect of "ablation", since a substance must absorb considerable heat to boil off a volatile material like carbon.

The effectiveness of sublimation in re-entry cooling has been shown for the case of a 100-lb satellite re-entering at four mps and 100 miles altitude for which certain simplifying assumptions are made (see *AvAge, "Sublimation May Lick Re-Entry Problem," Feb. '58, p. 27*). The re-entry heat transfer to this vehicle is about 12,300 btu. If we assume an effective frontal heat transfer area of one square foot, we get the extremely high heat flux rate of 86 btu/sec-sq in. (The heat flux in the throat of a rocket thrust chamber may be as low as 10 btu/sec-sq in.)

In this re-entry situation, a sublimating shield of beryllia could be used. At 4500 deg F, 10,600 btu would be absorbed by each pound of beryllia, so 46.5 lb of beryllia would be needed to protect our hypothetical satellite. Despite the beryllia's high surface temperature of 4500 deg F, the metal shell of the satellite proper would not be affected too much, thanks to the beryllia's low conductivity and the short exposure time.

As this case shows, the designer of any ablation shield is especially interested in the energy absorbed per unit mass of ablated material—the material's so-called "efficiency". During ablation, energy is transferred from a gas stream to the surface of a material by the action of

more on next page

aerodynamic heating. This energy is absorbed in the form of heat capacity and latent heat of vaporization (for that fraction of material which vaporizes).

Qualitatively the ablation efficiency can be expressed by the steady-state energy balance for ablation:

$$q_i = \dot{m}(h_T + fh_V),$$

where q_i is heat transfer rate per unit surface area; m, mass rate of material loss; h_T, heat capacity; f, fraction of vaporized material; and h_V, latent heat of vaporization. To keep down the rate of material loss—on which the efficiency depends—a high surface temperature and a high degree of vaporization obviously are needed, and the fraction of vaporized material should be near unity. With beryllia, these criteria can be met nicely; some plastics, such as polyethylene, whose molecules contain large amounts of carbon do even better.

Glasses favored for ablation

Glasses appear to be the favorites among ablation materials, even though there are "pure plastic" protective materials, such as polyethylene and polystyrene. The advantages of glassy materials are:

- high liquid viscosity at high temperatures, which favors the storage of energy as heat capacity and latent heat of vaporization before the liquid flows away because of aerodynamic shear;
- low thermal conductivity, which naturally reduces the heat transfer to the re-entry vehicle proper;
- high energy of vaporization;
- good thermal stress characteristics.

The last point is very important. Re-entry is not a gentle process, and there's obviously some danger that aerodynamic drag might completely tear away a material already weakened by thermal shock. To forestall such an effect, designers often reduce the brittleness of glassy material by special heat treatment or by the use of reinforcing or binding substances.

Recently it has been shown that, by impregnating porous glassy material with some plastic like epoxy, the tenaciousness and low conductivity of plastic can be combined with the advantages of glasses. The same results are obtained by mixing "semi-glassy" substances like asbestos and ceramic fibers with plastic.

In such combinations, the plastic forms a liquid film more quickly during re-entry than does the glassy material. Since this film is a very poor conductor of heat, it effectively protects the glass against the initial thermal shock, which normally might lead to sudden boil-off.

An entirely different method of re-entry cooling uses heat sinks (which more precisely ought to be called heat "sponges"). In this case, an inert mass—usually a metal body with good thermal conductivity—"soaks", or "sponges", up the heat as it is formed and stores it (possibly for later release during a cooling cycle).

The heat transferred to a heat sink and distributed throughout it by conduction must be less than the sink's heat-absorbing capacity. Otherwise the heat sink will reach its critical temperature and begin to melt.

The *transient* heat transfer condition of re-entry can be expressed simply as:

$$Q\Delta t = -KA(dt/dl)\Delta t = Wc'\Delta T,$$

where Q is heat transferred per second across the sink area A; K, heat conductivity (in btu/sq in.-sec-deg F/in.); Δt, heating time; ΔT, overall wall temperature increment; dt/dl, temperature gradient; W, sink weight; and C', average specific heat. With this rough approximation, the designer can quickly determine—to an order of magnitude—how much heat sink material he needs in a given case.

Since a heat sink *stores* heat, its design calls for a fairly large amount of material for a re-entry body like the Mercury capsule. The metal used for it therefore should be light. In addition, it ought to have good conductivity, a high melting point, and good oxidation resistance. Beryllium meets all these requirements and is actually used for the Mercury re-entry shield. Magnesium and aluminum are other promising re-entry heat sink materials.

One of the advantages of a heat sink for re-entry vehicles is that it can be used repeatedly without rework. Also, generally a heat sink can be said to give more positive protection than any ablation technique. Its big drawback is the weight penalty it imposes.

A less well-known, but nevertheless important, re-entry cooling method uses chemicals that absorb heat as their chemical composition is changed. Chemists long have been familiar with several substances that, when exposed to heat, suddenly turn colder. The very action of the heat causes a re-arrangement of the chemicals' molecules, and this re-arrangement absorbs heat.

In a re-entry design, a chemical with these heat-absorbing characteristics might be used as a powdered filler in a metal sandwich. When exposed to the heat of re-entry, the chemical would change from a solid into a liquid or maybe into a new compound and so absorb heat. In a sense, such a chemical would be a "negative heat sink." It would be more efficient than a conventional heat sink, which only absorbs heat until it is saturated and does not undergo a change of phase.

Re-entry cooling also can rely on the quite similar phenomenon of fusion heat. This is the heat required to melt a substance *without raising its temperature.* Once a substance like a metal has begun to boil, it is actually possible to transmit heat to it for several minutes without any significant temperature rise, for all the heat is used to melt the material.

The *Table* shows the heats of fusion of several materials. This heat obviously applies only until the melting process is complete; after that, any further heat transmission will raise the temperature again. The cooling effect thus lasts only for a very short period that depends on the mass of the material that is used.

Heat of solution can be used

Still another related phenomenon that can be used for re-entry cooling is the heat of solution. Occasionally, hydrated salts as well as salts that do not form hydrates dissolve endothermically. Usually this effect takes place in water, as in:

$$CaCl_2{\cdot}6H_2O + 394H_2O \rightarrow CaCl{\cdot}400H_2O - 4.56 \text{ cal.}$$

The calories in the last term of this equation represent the heat absorbed in the process. Other examples of endothermic reactions are the formation of acetylene (C_2H_2) and of monatomic hydrogen from H_2. The heat absorbed per gram molecule of these substances is 54.3 cal for C_2H_2 and 50.4 cal for H.

Most simple endothermic substances tend to be unstable. There are, however, various complicated carbonates and sulphates of calcium, magnesium, and aluminum that yield new substances in endothermic reactions that show no signs of chemical instability.

Re-Entry Materials

	Melting Point (deg C)	Oxidation Resistance[1]	Heat Conductivity[1]	Fabricability[2]	Cost[1]	Re-Entry Use	Remarks
Molybdenum	2620	poor	0.7	poor	high		needs protective copper coating
Titanium	1800	medium to poor	0.8	poor	high	uncooled leading edges	
Tungsten	3370	fair	0.9	fair	medium	uncooled outer shields	
Nickel	1455	fair to good	0.26	good	low to medium	cooling tubes	
Stainless steel (347)	1500	good	0.2	good	medium	outer shields	very good for general use
Mild steel	1430	fair	0.27	very good	low	inner liners	cheap; heavy per pound of heated material
Copper	1000	good	2.2	very good	low		heavy
Aluminum alloy (3S)	650	very good	1.2	very good	low		technology well understood
Magnesium alloy (6Al-0.2 Mn)	615	good	0.75	good	medium to low	lightweight shields	needs special inert-gas working conditions
Beryllium	1250	good		poor (as pure metal)			difficult to fasten to other metals
Ceramics & cermets (Niafrax, metal carbides)	3	very good	poor	poor	low	protective nose pieces	brittle; suffer from thermal shock

(1) Compared with values for pure aluminum. (2) Compared with the fabricability of aluminum alloys. (3) Indefinite; material usually good to 3000-4000 deg F.

Though the idea of using endothermic chemical reactions for re-entry cooling sounds simple, it poses tricky design problems. The main difficulty probably lies in finding a chemical that is so highly "endothermic" that not too much of it has to be used to forestall boiling even at the high rate of heat generation in re-entry. The choice of the material for the metallic sandwich covers also raises problems, for heat must be transferred to the chemical filler between the covers quickly enough to keep the metal skin of the vehicle proper from melting.

If all these problems could be overcome, we would have a highly efficient and simple re-entry cooling method. After use, the chemical could be flushed out of the metal sandwich and replaced with a new filler. The chemical would weigh little.—End

Designing hot-gas servos

for long missile flights

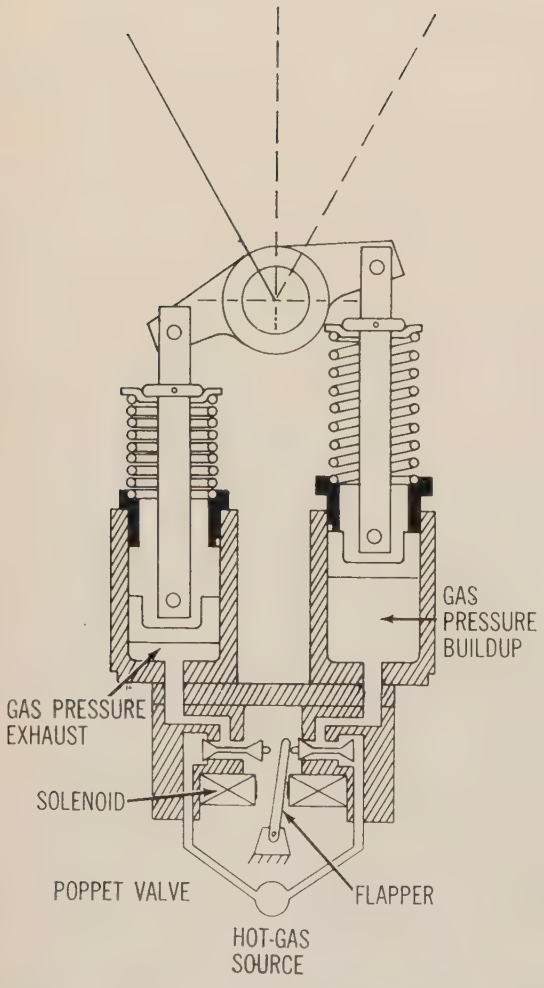


FIGURE 1: Three-position hot-gas servo control.

How tricky a hot-gas servo do you need to get long endurance? Here is an outline for a design procedure that will enable you to get by with just as little complexity as possible.

by Charles Delson, Mechanical Application Engineer, Armament & Control Section, Light Military Electronics Dept., General Electric Co.*

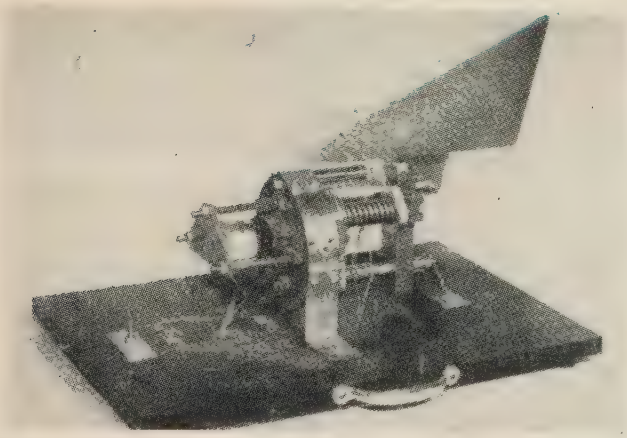
THE IDEAL APPROACH in designing hot-gas servos for long missile flights—say, from two to ten minutes—is to try for the simplest type of control scheme first. This is a two-position control (also known as the bang-bang or on-off type) with simple open or closed poppet valving.

Basically, this servo is a high gain device—small valve movement and low power consumption allow full gas flow. Hot-gas tests with solid propellant grains reveal that these poppet valves—despite the dirty exhaust products of solid propellant grains—operate for a long time without any loss in performance.

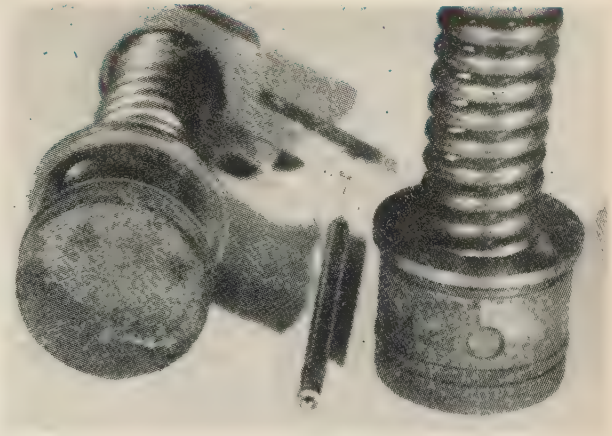
A computer study or system analysis must be made to check out the theoretical performance. If the on-off design is unsatisfactory, the next step is to try a three-position control (*Fig. 1*). In this type, the surfaces move a fixed maximum distance from neutral whenever the servo is energized. When no error signal exists, they are returned to neutral and held there in the null position by a detent force.

If this type also proves inadequate, the next step is to go to the slightly more complex five position con-

* Light Military Electronics Department, General Electric Co. Johnson City, N.Y.



TEST MODEL of a hot-gas servo assembly designed to use solid propellant grain.



PISTON after operation with solid propellant grain. Etching on surfaces, caused by acids in the grain.

trol (*Fig. 3*). Here the surfaces are given a maximum deflection right after launch or just before impact. A small amount of control surface movement is possible during midcourse flight for trim change or stability augmentation.

Bang-bang simplicity is retained

This small control movement also provides better roll stability about the longitudinal axis. Although the five-position control design is the most complex, it retains the inherent simplicity and reliability of bang-bang valve operation.

Many hot-gas servo packages using this type of control have been designed, and several of them have been tested at GE. The test program has followed the regular pattern of (1) operation at room temperatures and then successively with (2) 1000-deg F nitrogen gas, (3) filtered solid propellant exhaust products, and (4) unfiltered exhaust products. All the solid propellant testing so far has been done with ammonium nitrate oxidizer base propellants that generate gases at about 2000 deg F. (Ammonium nitrate was chosen over a double-base propellant because of its lower burning rate.)

Better propellant grain in view

One of the big problems in hot-gas servo development work is to find a grain that will burn for a long time without breaking down the inhibiting material. Propellant manufacturers are quite optimistic about their ability to supply such grain in the near future. As an interim solution to the problem it is possible to connect several short duration grain generators to a common manifold and fire them in sequence.

System or computer studies might indicate that a standard three- or five-position control is just not the answer. In that case, variations should be considered.

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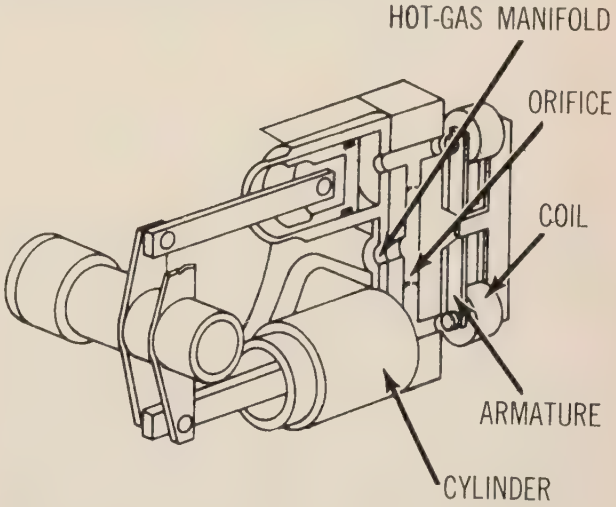
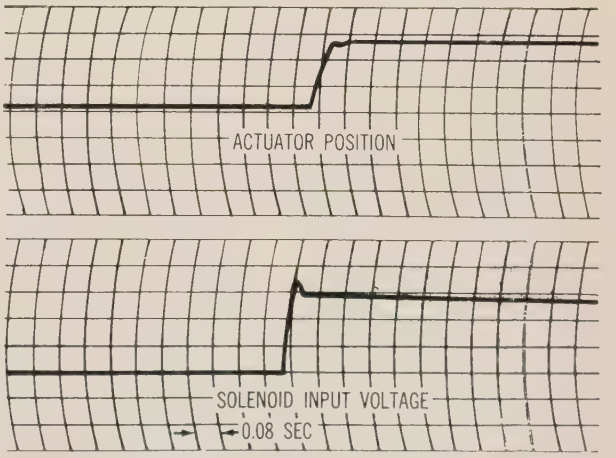
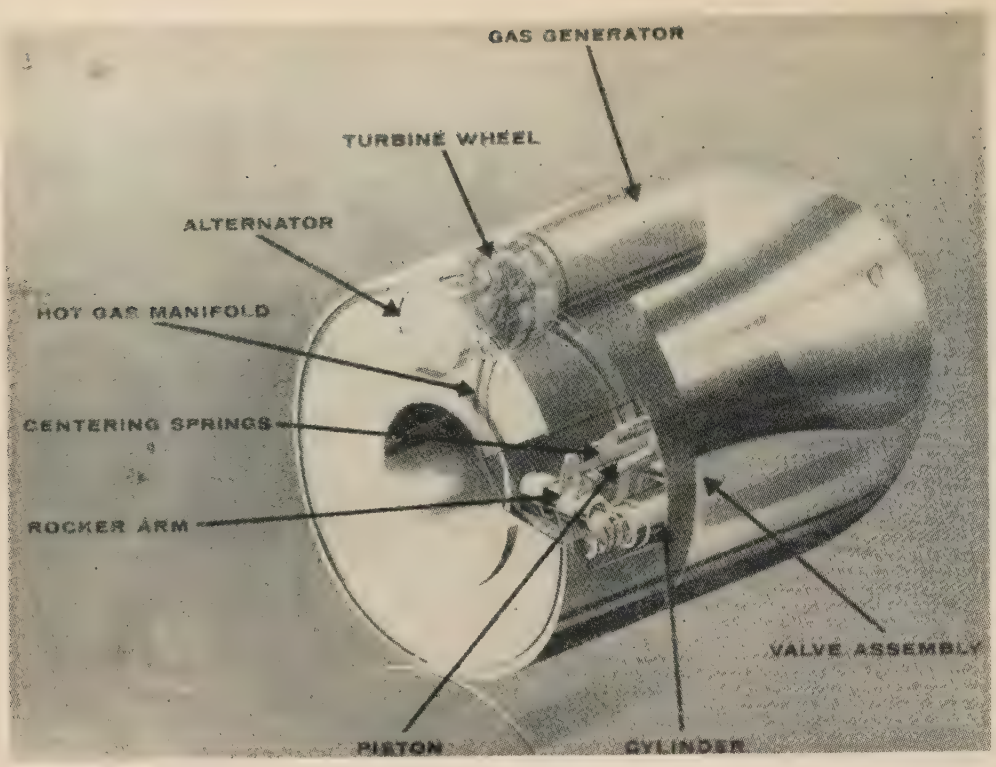


FIGURE 2: Pulse-modulating hot-gas servo.



TRANSIENT-RESPONSE of a typical hot-gas servo at a load of 2000 lb/in. and a pressure of 1000 psi.



TYPICAL hot-gas servo package.

For instance, the actuator pistons can be sized to give maximum deflection at predetermined missile velocity and altitudes. At higher speeds or lower altitudes, the deflection would be reduced, so that the surface control force would remain fairly constant.

Another variation would be to time-modulate the period during which the valve remains open. The actuator would "move" to the desired position only for a while and drop back to null when the pressure is removed. Many other variations are possible by tailoring the control closely to the missile airframe's aerodynamic characteristics, the mission profile, and the available sensors.

Proportional control problematic

Should all attempts with a discontinuous-type control fail, then the only recourse is to go to a proportional control system. For long flight times, this is a problem. All the disadvantages of the dirty, hot solid propellant gas come into play and start cutting down the reliability. Null shift, erosion of critical valve and orifice surfaces, temperature differences between materials, and changes of friction level all become a lot more critical, with an increase in duty cycle.

Here again, the better approach seems to be to deviate somewhat from the truly proportional type of control. It may be better to use high frequency switching of the control valve and modulate the pulse space or length of the valve seating (*Fig. 2*). Full seating of the valve on its seating surface tends to break away any adhering exhaust particles and permits larger equivalent orifice clearances across the valve.—End

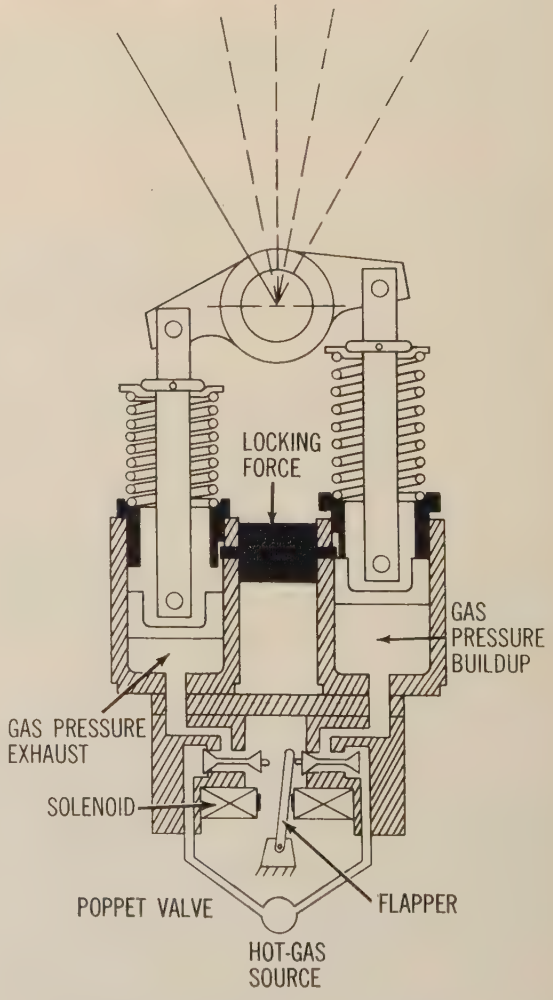


FIGURE 3: Five-position hot-gas servo control.

Power-spectral analysis gives better gust load data

Like so many of the dynamicist's traditional tools, yesterday's methods of gust load analysis are proving inadequate for today's high performance aircraft and missiles. Here is a report on new statistical methods for mathematically describing the atmosphere that promise to bring gust load determination into step with the times.

by T. A. Siciliano and W. J. Oakes,
Engineer & Applications Engineer, resp., Norair Div., Northrop Corp.*

DESIGNERS HAVE LONG known that the "discrete-gust approach", in which gusts are accounted for in terms of discrete gust shapes and velocities, is artificial. In reality, atmospheric turbulence is a continuous phenomenon, and the vehicle is subjected to repeated loads covering the entire range of frequency and amplitude.

In recent years, much progress has been made in applying theoretical analyses of airplane behavior to determine gust loads more realistically. To some extent, it followed the development of mathematical methods for estimating mean-square-density distributions from random-function variations with time and space. More familiarly this term is known as the "power-spectral-density distribution". The principle of "general harmonic analysis", attributed to Norbert Wiener, and the concept of linear system analysis combine to form the basis of the theory by which power-spectral methods are used to analyze the random disturbances of vehicles that are caused by atmospheric turbulence.

We will deal here with two promising basic methods for experimentally determining turbulence spectra:[2] the "transfer-function method" and the "direct method".

The transfer function method is based on the relation between the power spectrum of the response of a linear system and the frequency-response function of the vehicle that is caused by unit input gust disturbances, or:

$$\phi_i(f) = \Phi_o(f) \mid T(2\pi_i f \mid^2 \quad (1)$$

where $\Phi_i(f)$ is the power-spectral-density function of a random input disturbance (gust velocity); $\Phi_o(f)$, the power-spectral-density function of vehicle response (normal acceleration at CG); and $|T(2\pi_i f)|^2$, the frequency response function, modulus square (normal acceleration at CG caused by oscillating gust), with subscripts i and o denoting input and output.

The frequency-response function of the Northrop F-89D fighter for gust disturbances (*Fig. 4*) was estimated theoretically; following the concept of linear system analysis, we solved the airplane equations of motion for a sinusoidal gust disturbance.[3] The validity of the gust spectrum given by *Equation 1* depends on the reliability of this calculated function.

The computational method we used to find the power spectrum (in both transfer and direct methods) was developed by Press and Tukey.[4] *Figure 1* shows the out-

(1) Norair Div., Northrop Corp., 1001 E. Broadway, Hawthorne, Calif.

(2) H. Press & J. C. Houbolt, "Some Applications of Generalized Harmonic Analysis to Gust Loads on Airplanes;" *J. Aero. Sci.*, 22/1 ('55). R. G. Chilton, "Some Measurements of Atmospheric Turbulence Obtained from Flow-Direction Vanes Mounted on an Airplane;" NACA, TN 3313 ('54).

(3) H. M. Nichols, N. B. James & R. S. Phillips, "Theory of Servomechanisms" (chap.2); McGraw-Hill ('47).

(4) Press & J. W. Tukey, "Power Spectral Methods of Analysis and Their Application to Problems in Airplane Dynamics;" Agard, Flight Test Manual, vol. 4 ('56).

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Table I: Airplane Configuration

Weight (W)	37,840 lb
Wing Aera (S)	606 sq ft
Average chord ($\bar{c}$)	12.13 ft
Average flight altitude	3000 ft
Average air density (ρ)	0.002175 slugs/cu ft
Airspeed (V)	620 fps
Slope of lift curve per radian (m)	5.62
Mass parameter (K)	94
$\sqrt{l(K,s)/\pi}$ (L=1100)	0.466
Gust response factor (k_g)	0.732

Table II: Combined Number of Gust Accelerations or Velocities Equaling or Exceeding Indicated Values[1]

Gust Velocity (U_{de}, fps)	Acceleration (Δn, g)	Cumulative Frequency[2]
5.35	0.25	11,818
7.50	0.35	6,774
9.65	0.45	3,193
11.80	0.55	1,556
13.95	0.65	685
16.10	0.75	336
18.25	0.85	142
20.40	0.95	73
22.55	1.05	32
24.70	1.15	16
26.85	1.25	11
29.00	1.35	7
31.15	1.45	3
33.30	1.55	2
35.45	1.65	1

(1) Total flight time of 9456 seconds. (2) Including positive and negative counts.

put power spectrum for the transfer method as a function of frequency *(f)* along with the 95 per cent confidence bands for the measured spectrum. There are four basic considerations in setting up an experiment for a power-spectral-density function:

- the choice of sampling interval (Δt),
- the number of lags *(m)* to be computed for the correlation and power-spectral functions,
- the length of record *($n\Delta t$)* needed to estimate the power spectrum within the prescribed confidence,
- the numerical procedure for computing the power spectrum.

Figure 2 shows an inverse plot of gust power spectrum obtained by the transfer method as a composite wide-band spectrum for wavelengths from 100 to 50,000 ft. The empirical spectrum is also compared to a theoretical spectrum to find the degree of correlation between results. These results may also be compared with the gust power spectrums obtained from vane measurements (*Fig. 3*) to show the correlation between methods of analysis.

As *Figure 3* shows, the empirical spectrum is widely scattered from the theoretical at the shorter and longer wavelengths. However, for our analysis a minimum wavelength of 200 ft is significant, since it represents 6-7 times the tail length. We assume that, under this condition, the aircraft is completely immersed in a uniform vertical gust velocity distribution at any instant of time along its X-axis.

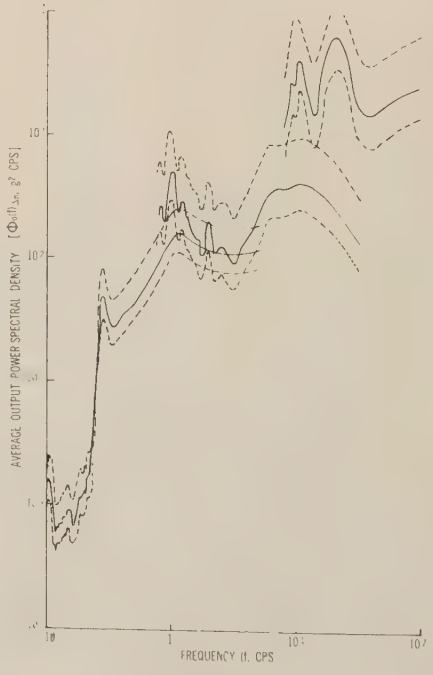
At the larger wavelengths (long-period band), little statistical reliability is to be expected, since the accumulation of data in this range is small. The lack of data is due to the difficulty of transversing gusts of these wavelengths without pilot input and to the assumption that atmospheric turbulence is a stationary, Gaussian random process.

Theoretical analysis of atmospheric turbulence showed that the theoretical gust spectrum given by the following expression closely approximated the empirical results:

(2) $\phi_i(f/V) = \sigma_G^2\, 2L[1 + 3(2\pi fL/V)^2]\,[1 + (2\pi fL/V)^2]^2$.

So the theory indicates that the gust power spectrum (vertical velocity) depends on two parameters: the RMS deviation of gust vertical velocity (σ_G) and the space scale of turbulence (L).

FIGURE 1: Composite wide-band spectrum of CG-normal acceleration, including 95 per cent confidence bands (dashed), for an F-89D flight for $\sigma\Delta_n = 0.19$ g and $\Delta n = 0.015$ g.



In a direct method, gust vertical velocity, the quantity for which power-spectral density is needed is found from the difference between air motions relative to the vehicle and vehicle motions relative to inertial space. This method considered the vehicle as a base from which continuous measurements are made.[5] If we assume that all angles are small variations from the steady state, the trigonometric functions have small-angle values, the nose boom is rigid, variations in boom upwash are negligible, and no relative structural deflections occur between points of measurement, we can write the sum of the measured or calculated quantities:

(3) $$\Delta w_g = V(\Delta\alpha - \Delta\theta) + l\dot{\theta} - \Delta w_a,$$

where Δw_g is gust incremental vertical velocity (in fps); $\Delta\alpha$, vehicle incremental angle of attack (in radians); $\Delta\theta$, vehicle incremental pitch attitude (in radians); Δw_a, vehicle incremental vertical velocity (in fps); V, vehicle forward velocity (in fps); l, distance from angle-of-attack vane to vehicle CG (in feet); and $\dot{\theta}$, vehicle rate of pitch (in rad/sec).

Vane measurements are primary

The primary quantity in this method is the vane measurements; all other quantities are correction terms for describing the reactions of the vehicle. The only quantity that is not measured directly is the vehicle's

(5) C. B. Notess & G. H. Eakin, "Flight Test Investigation of Turbulence Spectra at Low Altitude Using a Direct Method for Measuring Gust Velocities;" Cornell Aero. Lab., Report VC-839-F-1 ('54). H. L. Crane & Chilton, "Measurements of Atmospheric Turbulence over a Wide Range of Wavelengths for One Meteorological Condition;" NACA, TN 3702 ('56).

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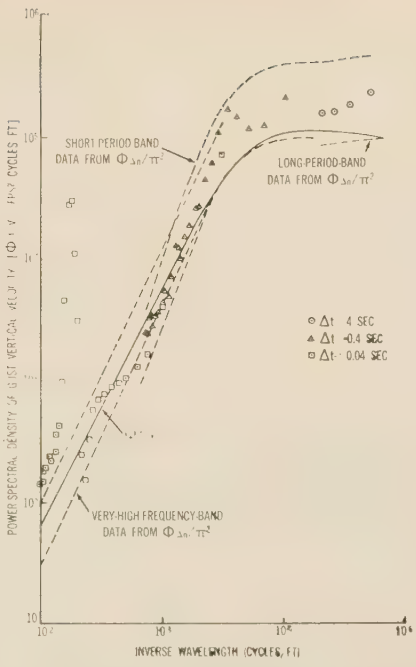
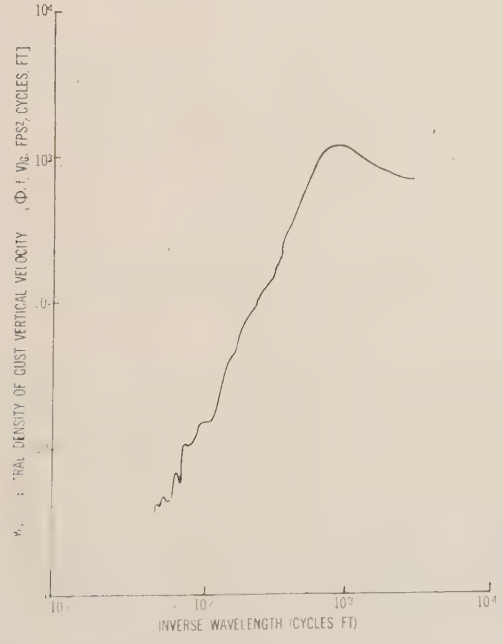
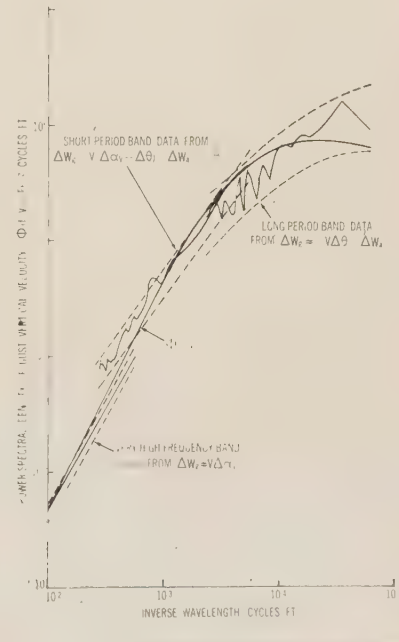


FIGURE 2: Inverse plot of gust power spectrum provided by the transfer-function method for wavelengths from 100 to 5000 ft. Data is taken from a Northrop F-89D flight described by Barrett; 95 per cent confidence bands are based on statistical reliability of the data and shown for arbitrary smooth fairings. For $\Phi(f/V)$, L = 1100 ft, σ_G = 6.8 fps, and V = 620 fps.

FIGURE 3: Gust power spectra provided by the direct method as inverse plots taken from vane measurements for the same F-89D flight (left) Figure 3, with the curve based on data for $\Delta W_g = V\Delta\alpha$, and for a McDonnell F2H-1 flight (right) described by NACA researchers Crane and Chilton. For the F2H-1 flight, the composite wide-band spectrum is shown for wavelengths from 100 to 60,000 ft as well as the 95 per cent confidence bands for arbitrary smooth fairings, with $\Phi(f/V)$ based on L = 1000 ft, σ_G = 5+ fps, and V = 290 fps.





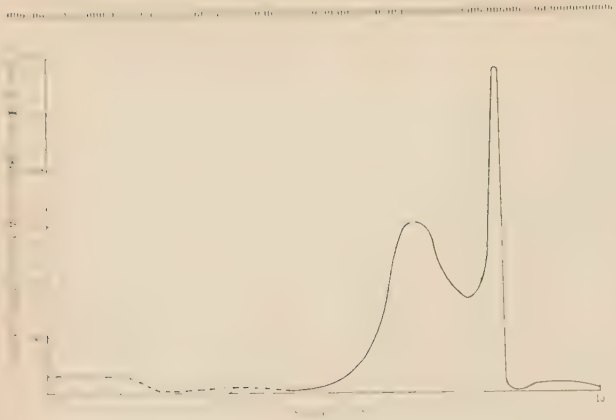


FIGURE 4: Theoretically estimated F89-D transfer function for sinusoidal gust at Mach 0.55, 3000 ft altitude, 24 deg C ambient, and 36,528 lb gross weight, with the accelerometer at station 234 and the CG at station 262.7. The dashed part of the curve was extrapolated.

vertical velocity. This is found from numerical integration of the recorded vertical accelerations. A time history of the gust velocities obtained from this method is used as the random function to be analyzed for determining the gust power spectrum directly without the aerodynamic transfer function (*Fig. 2*).[6]

Currently, the discrete-gust-loads formula of Mil-S-5702 is used to find the equivalent gust velocities from discrete measurements of acceleration:

$$U_{de} = (498\ W/S)\ \Delta n_{meas.}/K_g V_e m, \tag{4}$$

where Δn_{meas} is measured normal incremental acceleration (in g); K_g, gust factor based on the mass ratio; V_e, equivalent vehicle forward velocity (in knots); U_{de}, derived equivalent gust velocity (in fps); m, slope per radian for the lift curve; W/S, total wing loading (in psf).

Values of U_{de} are determined for a single (1-cosine) gust of 25 wing MAC lengths. They depend on K_g, which accounts for the alleviated motion of the vehicle and the time lag of the buildup of aerodynamic lift. We used this approach to find the U_{de} values—from measured normal accelerations and average airplane characteristics (*Table I*)—for the F-89D in non-storm turbulence at low altitudes (*Table II*).

As a result of the work of S. O. Rice and many others on the theory of random processes, various relations between peak counts and the associated power spectrum have already been derived. These apply to the case of a stationary, Gaussian random process. Stationarity implies that the statistical quantities don't vary with times or space, and the term "Gaussian" refers to a process distinguished by a Gaussian probability distribution for the intensity of the disturbance as well as its other moments. Unfortunately, atmospheric turbulence isn't a stationary Gaussian process, since it varies in intensity with altitude and weather conditions.

However, it can be assumed to be locally stationary and Gaussian—i.e., its statistical properties are Gaussian and fixed for short periods of time and space but vary in intensity from time to time and place to place. So if the operational gust history is considered a non-stationary Gaussian random process varying only in the intensity of RMS gust velocity, the problem of defining the gust history is reduced to that of defining the probability distribution of the RMS gust velocity. For this analysis, it appears possible to extend Rice's findings to derive a basis for estimating the distribution of RMS gust velocity from counts of acceleration peaks.

Two approaches are suggested for this estimate: in one the RMS gust velocity takes on only a few discrete values, in the other its values cover a continuous range. We will discuss here only the second, more realistic approach.

The distribution is derived from the data of *Table II* and by power-spectral analysis, and the gust intensity for weather and altitude conditions is estimated.

Average exceedences are found

If the vehicle is assumed to meet turbulences of all intensities but of the same spectral shape, then the average number of peak acceleration exceedences for given accelerations is found from:

$$\overline{M(\Delta n)} = \int_o^\infty N(\Delta n) f(\sigma_{\Delta n}) d\sigma_{\Delta n}, \tag{5}$$

where

$$N(\Delta n) = N_o e^{-(\Delta n/\sigma_{\Delta n})^2/2},$$

$$N_o = \left[\int_o^\infty f^2 \Phi_{\Delta n}(f) df \Big/ \int_o^\infty \Phi_{\Delta n}(f) df\right]^{1/2},$$

$$f(\sigma_{\Delta n}) = (2/a)\ (e^{-(\sigma_{\Delta n}/a)^2/2}/\sqrt{\pi}),$$

$$\sigma_{\Delta n}^2 = \int_o^\infty \Phi_{\Delta n}(f) df,$$

with N_o being a fixed constant for a given vehicle.

Equation 5 can be integrated in closed form and yields the cumulative distribution for peak acceleration exceedences for the continuous case:

$$\overline{M(\Delta n)}/N_o = e^{-\Delta n/a}. \tag{6}$$

For $a = 0.165$, *Equation 6* closely approximates the observed values of *Table II*.

To get the probability density function of the RMS gust velocity and the average number of maximum and minimum gust disturbances per mile exceeding given values of gust velocity, an analysis of vehicle dynamics and parameters is needed. Y. C. Fung has found a direct proportion between RMS gust velocity and acceleration:

$$\sigma_{\Delta n} = \overline{A}\sigma_G, \tag{7}$$

where $\overline{A}$ equals $\rho V m \sqrt{I(K,s)\pi/(2W/S)}$. A direct proportion between gust velocity and acceleration can be derived from *Equation 4:*

$$\Delta n = \overline{C} U_{de}, \tag{8}$$

where $\overline{C}$ equals $K_g V_e m/(498 W/S)$. The distribution of RMS gust velocity for clear-air (light to moderate) turbulence is obtained by transforming $f(\sigma_{\Delta n})$ by $f(\sigma_G) = \overline{A} f(\sigma_{\Delta n})$:

$$f(\sigma_G) = (2/b)\ (e^{-(\sigma_G/b)^2/2}/\sqrt{2\pi}), \tag{9}$$

where b equals $a/\overline{A}$.

Figure 5 compares the distribution obtained from *Equation 9* for $b = 5.8$ with distributions obtained from three meteorological conditions.[7] The average RMS gust

(6) J. O. Barrett, "Preliminary Study of Atmospheric Gust Conditions at Low Altitudes;" WADC, TR 57-253 ('57).

(7) Press et al., "A Reevaluation of Data on Atmospheric Turbulence and Airplane Gust Loads for Application in Spectral Calculations;" NACA, TR 1272 ('56).

velocity obtained with the transfer-function method was slightly less than seven fps. We found that gust velocity intensities of this magnitude would occur not more than two per cent of the total flight time at low altitudes.

Direct method gave fps

With the direct method, the average RMS gust velocity worked out to five fps. We found that intensities of this magnitude would occur not more than 20 per cent of the time and not more than six per cent of the total flight time at low altitudes.

By transforming *Equation 5* and using the relation of *Equation 9*, we can write the average number of gust disturbances (up and down gusts) per mile exceeding given values of gust velocity for various types of storm conditions as:

$$(10) \quad \overline{M(U_{de})} = M_o \int_o^\infty \hat{f}(\sigma_G) e^{-\{U_{de}/[\sigma_G(\overline{A}/\overline{C})]\}^2/2} d\sigma_G,$$

where M_o, equaling $5280(2N_o)/V$, is the average number of gusts per mile exceeding zero and is a fixed constant for a given vehicle;

$$\hat{f}(\sigma_G) = P_{NS} f_{NS}(\sigma_G) + P_S f_S(\sigma_G),$$

P_{NS} and P_S are the proportions of total flight time spent in nonstorm and storm turbulence at given altitudes, respectively; and $f_{NS}(\sigma_G)$ and $f_S(\sigma_G)$, the probability density distributions of RMS gust velocity for nonstorm and storm turbulence, respectively, and depend on b.

If we assume that the distribution of RMS gust velocity for the non-storm and storm conditions can be represented by *Equation 9*, then *Equation 10* can be integrated in closed form:

$$(11) \quad \overline{M(U_{de})} = M_o P_{NS} e^{-U_{de}/b_{NS}(\overline{A}/\overline{C})} + P_S e^{-U_{de}/b_S(\overline{A}/\overline{C})},$$

where $b_{NS,S} = m_{NS,S}\ k_{NS,S}\ C/\overline{A}$ and depends on air density, gust intensities, and gust factors; $k_{NS,S}$ is a factor describing variations in turbulence intensity with altitude[8]; and $m_{NS,S}$, the slope of overall gust velocity distribution for non-storm and storm conditions, respectively. *Figure 6* shows various distributions of gust velocity for non-storm turbulence at low altitudes that were obtained with this analysis.

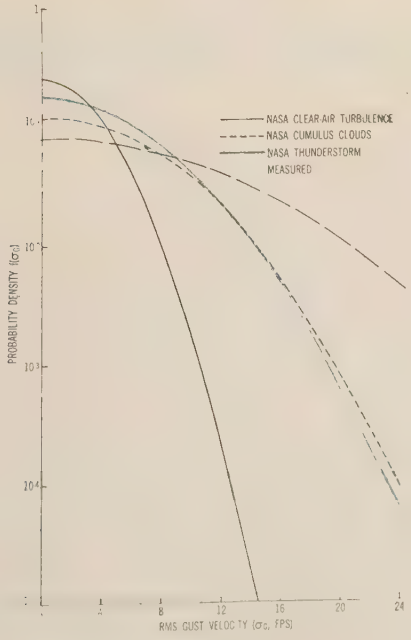
Theoretical prediction upheld

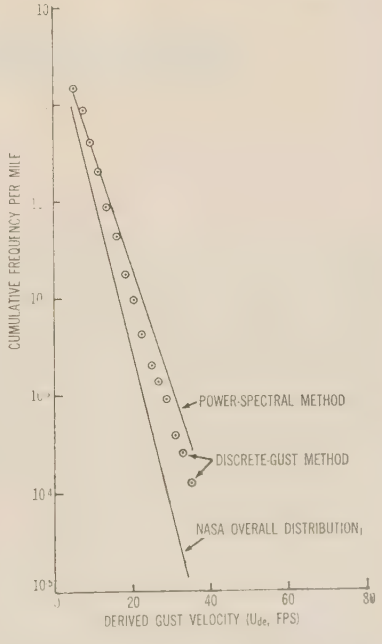
Although the power spectrum of atmospheric turbulence derived by the transfer-function method leaves much to be desired, it conforms with other experimental spectral analyses to the extent that the power decreases rapidly for small changes in frequency. We have seen that the gust power spectrum at the higher frequency end of the spectrum decreases at a rate of —2 power (l/f^2), which had been predicted theoretically. The spectrum also tends to flatten out at the lower frequency end, which gives an indication of the scale of turbulence (L).

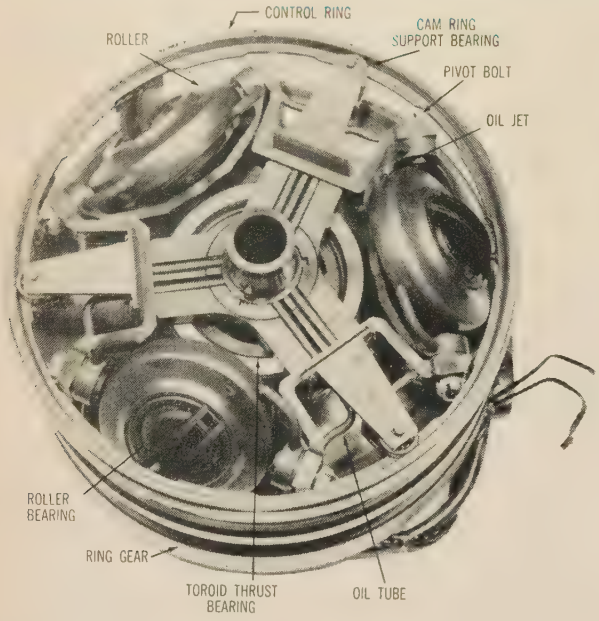
In comparing the curves of *Figure 5*, note that the estimates of the gust distribution based on CG-normal-acceleration measurements in this analysis weren't corrected for amplifications in airplane CG acceleration that are due to the effect of vehicle flexibility. The U_{de} values in *Figure 5* would be amplified, according to those effects, but the amplification that is actually shown is due to the NASA distribution. We believe that a reduction of 20 per cent in acceleration (and associated velocity) measurements is necessary.—End

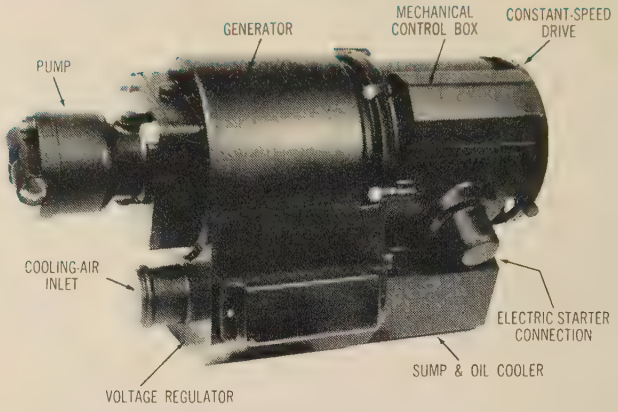
(8) Press & R. Steiner, "An Approach to the Problem of Estimating Severe and Repeated Gust Loads for Missile Operations;" NACA, TN 4332 ('58).

FIGURE 5: Comparison (left) of distribution of RMS gust velocity from Equation 9 for light to moderate turbulence with distributions from three meteorological conditions. Right: Comparison of overall gust velocity for non-storm turbulence derived from low altitude measurements on the F-89D of power-spectral and discrete-gust analyses with NASA's overall distribution at low altitudes. The proportion of flight time in turbulence was 0.25 at 2000-4000 ft altitude for the power-spectral method and 0.32 at zero to 2000 ft for the NASA distribution.









ROLL STEERING mechanism (left) needs less than one inch-pound of power to change the roll tilt and so increase or decrease the output toroid's speed. Above: CSD power system designed by Lycoming for Republic's AN/USD-4 Swallow surveillance drone. The integrated design package puts out 100 amp dc, 10 kva ac, and 9.6 gpm (hydraulic fluid) at 3000 psi.

Fast R&D pace set for

mechanical constant-speed drives

Efficiencies of 80-85 per cent at low power and over 90 per cent at high power, frequency control within two and 0.25 per cent, and uncooled operation at 600 deg F are claimed by Lycoming for its 10-120-kva traction-type CSDs—which are among the mechanical designs that are threatening to make conventional hydromechanical drives obsolete.

by **Victor de Biasi,** Associate Editor

FIVE YEARS AGO, engineers were not sure a mechanical constant-speed drive (CSD) could be developed to match the conventional hydromechanical units. Today, the mechanical CSD threatens to make the others obsolete. How it will stack up against the electric variable-speed, constant-frequency generators remains an open question.

Lycoming Div., Avco Mfg. Corp., Stratford, Conn., started the development of a mechanical, or traction-type, CSD in late 1954. Several months were spent in playing around with conical drive plates and friction rolls—with little success. Eventually, a more promising, toroidal-drive scheme was chosen.

In 1955, the Navy gave Lycoming a contract to develop a 20-kva drive. By July 1958, this design completed its Navy Mil-T-7101A qualification tests—some-

thing the hydromechanical drives still have to do, Lycoming says.

Republic's Swallow surveillance drone will be the first vehicle to use a production model of Lycoming's drive. In the meantime, Lycoming also has a development contract from North American for a 40-kva drive for —65 to +600 deg F.

According to chief engineer C. D. Flanigan, Lycoming plans to develop a series of drives ranging from 10 to 120 kva. He believes these drives will be able to operate mostly without external oil cooling. As a result, it is possible to design them as integrated, leakproof packages without any external plumbing connections (except for an air blast line to the integral oil cooler).

Lycoming is working on several design variations to develop its Navy-qualified 20-kva drive further. In the process, it has:

- run durability tests under full-load conditions in which standard 20-kva units were operated continuously at 300 deg F for over 500 hours and intermittently for one-hour periods at 365 deg F;
- reached power levels of 175 hp, at which the efficiency was over 90 per cent, with a modified 20-kva drive that has a normal load rating of 30 hp;
- operated modified 20-kva units with the oil inlet temperature at 600 deg F and without cooling for a total of over 50 hours (with single runs of up to five hours).

Advanced control systems sought

A major R&D effort is also being put into the development of advanced control systems for both single- and parallel-drive installations of all sizes:

- *A primary mechanical control system* for two per cent frequency control under steady-state and full-transient-load conditions—Over 75 hours' testing has been completed on a mechanical governor and actuator design. Two per cent control has been achieved, but only after careful selection of spring tolerances, parts alignment, etc. The aim is to get two per cent control from routinely assembled and adjusted units operating under field conditions.
- *A precise electric trim system* to bias the mechanical control to keep the frequency within 0.25 per cent at steady-state conditions—The basic design and operating principles have proved out in several other applications; they have already been proof-tested in a mechanical drive unit. Essentially the electric system continuously changes the governor spring loading to make up for any frequency error. Electric failure would have no effect on the mechanical control.
- *Automatic paralleling and load sharing* for aircraft and missiles powered by two or more drives—Most of this work is concentrated on the development of a mechanical load sharing system. Two design variations are being tested. Some bugs still have to be ironed out, but the basic solution has been proved sound. Mechanical load sharing is expected to be more reliable and more stable than electric sharing under transient conditions.

The heart of Lycoming's CSD is the traction-type transmission (*Fig. 2*). Its basic elements are two facing toroids separated by three wheels, or rolls, mounted in a fixed cage. When the input toroid is turned, the rolls spin and exert a tractive force on the facing toroid. Power is transmitted through friction, with the efficiency depending primarily on how tightly the rolls can be squeezed between the toroids.

The rolls can be tilted—or, more accurately, steered—to different angles to change the output speed. If they are steered so that they make surface contact near the rim of the second toroid (and the center of the first),

more on next page

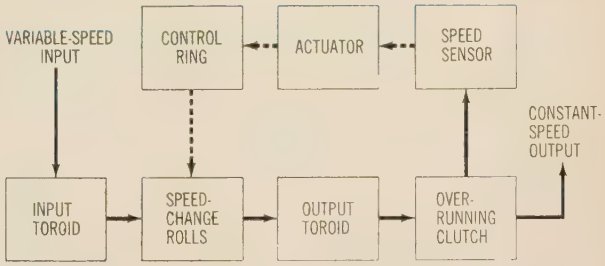


FIGURE 1: In Lycoming's mechanical CSD, power is transmitted from the input to the output toroid through the speed change rolls. Speed is sensed by a flyball governor, which delivers an error signal to the actuator whenever the output rpm changes. The signal actuates the control ring to change the tilt of the speed-change rolls so that the rpm is held constant regardless of changes in input speed or system load.

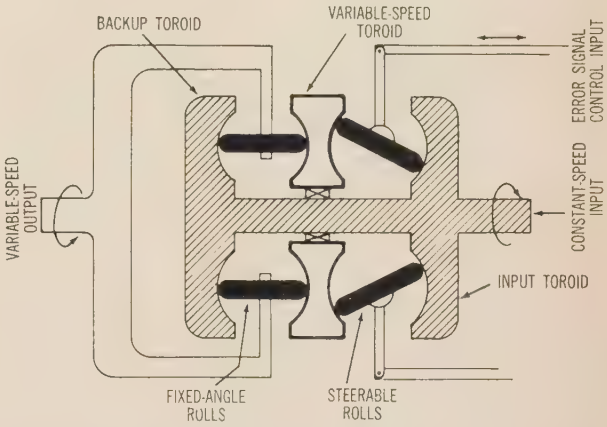


FIGURE 2: The mechanical actuator of Lycoming's CSD is a toroid differential. A linear "velocity error" signal from the speed sensor tilts the input rolls, which changes the rpm of the variable-speed toroid. The fixed-angle rolls now are in contact with the constant- and variable-speed toroids in such a way that the assembly "tracks", or rotates, to make up for the speed differential. This basic scheme could be adapted in an all-mechanical flight control system to actuate the control surfaces in direct response to pilot stick displacement.

Performance Characteristics of Proposed 120-KVA Constant-Speed Drive

Input speed	4475-8000 rpm
Output speed	6000 rpm
Load	
Continuous	167 hp
Five minutes	255 hp
Three minutes	302 hp
Five seconds	332 hp
Speed regulation	
Steady state	⅜ per cent
Transient frequency deviation (100% load change)	5 ½ per ceet
Film	GE F-50 chlorinated silicone system or equivalent
Max. heat rejection at rated load	650 btu/min
Min. efficiency at rated load	92 per cent
Fluid operating temperature range	−65 to +400 deg F
Ambient temperature range (transmission)	−65 to +250 deg F
Altitude	0-70,000 ft

the output speed drops. Steering in the opposite direction increases the output speed.

Regardless of the roll angle, the linear distance between points of contact remains fixed, because of the concavity of the toroids and the roll design. Operating wear is reduced by steering the rolls to different angles rather than dragging them across the toroid surfaces. An eccentric yoke arrangement does the steering so that control ring forces can be very light. The level of the mechanical actuator force is normally about one inch-pound; it is geared up to about 400-500 in.-lb. at the control ring, or about ten times the maximum control ring demand.

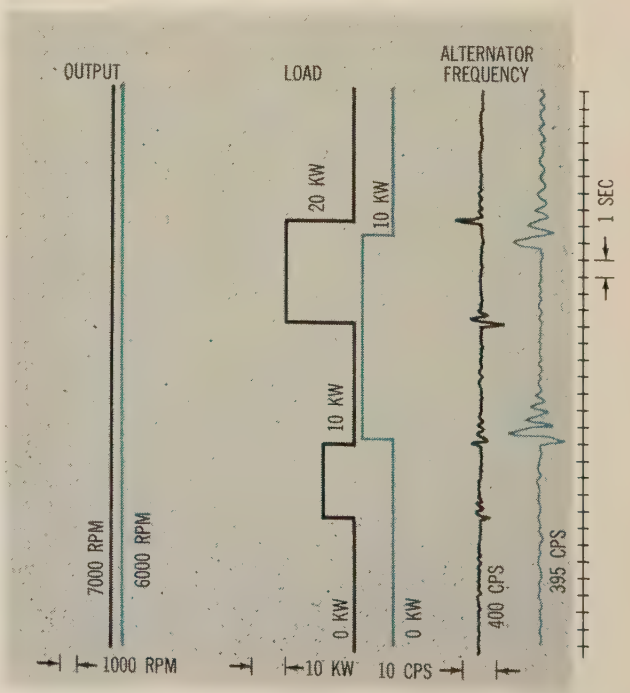
A flyball governor geared to the output toroid shaft senses output speed. Any underspeed or overspeed condition moves a linkage to send an error signal to a mechanical actuator (*Fig. 1*). There the signal is mechanically boosted to power the control-ring gearing. The servo response is fast enough to hold the output-shaft speed within four per cent of the design speed under both steady-state and full-transient load-change conditions.

This primary mechanical control is backed up by an electric precise-frequency control system that derives its frequency signal and power from a PM generator driven off the output gearing. The ac signal that is generated is matched to a tuned circuit. Any error signal is then amplified to energize a servo motor in the control-ring gearing and steer the rolls to a more precise speed-control position. With this electric control, output rpm without any trouble can be held within one per cent of the design speed even under full-transient-load-change conditions.

The power capacity is directly related to the roll squeeze force and the number of rolls. To go up in

Materials for 600-Deg F CSD

Rolls & toroids	Ferrovac Halmo & T-5 Rex Supercut
Gears	nitrided Inco 5Ni-2Al Super Nitralloy & M-10 high speeds tool steels
Bearings	Ferrovac Halmo, M-50 tool steel, 440 C stainless steel races & balls
Cages	chrome-plated S-Monel, S-Monel, iron-silicone bronze
Gear-type pump elements	Nitralloy, M-10 tool steel (in Meehanite housing)
Housings & covers	321 stainless steel weldments
Structural parts	Vascojet 1000
Springs	Inconel X
Shaft seals	Graphitar against flame-plated tungsten carbide
Gaskets	Duroid 5600, Raybestos Manhattan A56



TEST RESULTS for the primary control loop of an experimental breadboard system operating in ambients of −65 deg F (black traces) and +600 deg F (color traces, for an oil inlet temperature of 617 deg F).

size, you tighten up on the roll "load bolt", which provides greater traction, and put in more rolls to distribute the load. The bolt is tightened upon assembly to preload the toroid thrust bearings so that the toroid surfaces bear up tight against the rolls.

Load bolt "stretch" is offset

To take care of the decrease in modulus of elasticity at higher temperatures, a low-thermal-expansion material is used for the load bolt. When the gearing heats up, the thermal expansion of the toroids and rolls more than offsets any "stretch" in the load bolt. The preload actually increases as the temperature goes up. Despite other factors, which tend to reduce the transmission efficiency, the overall result is that the power capability remains basically unchanged over the full range of temperatures to about 300-400 deg F.

A completely different design technique is used for operation at higher temperatures. According to Flanigen, all the design obstacles have been cleared away, and the solutions have been proved out in bread-board tests. All that remains is to design and qualify a prototype production unit for the NAA 600-deg F development contract. High temperature materials were used, of course, and major design changes were made in several areas:

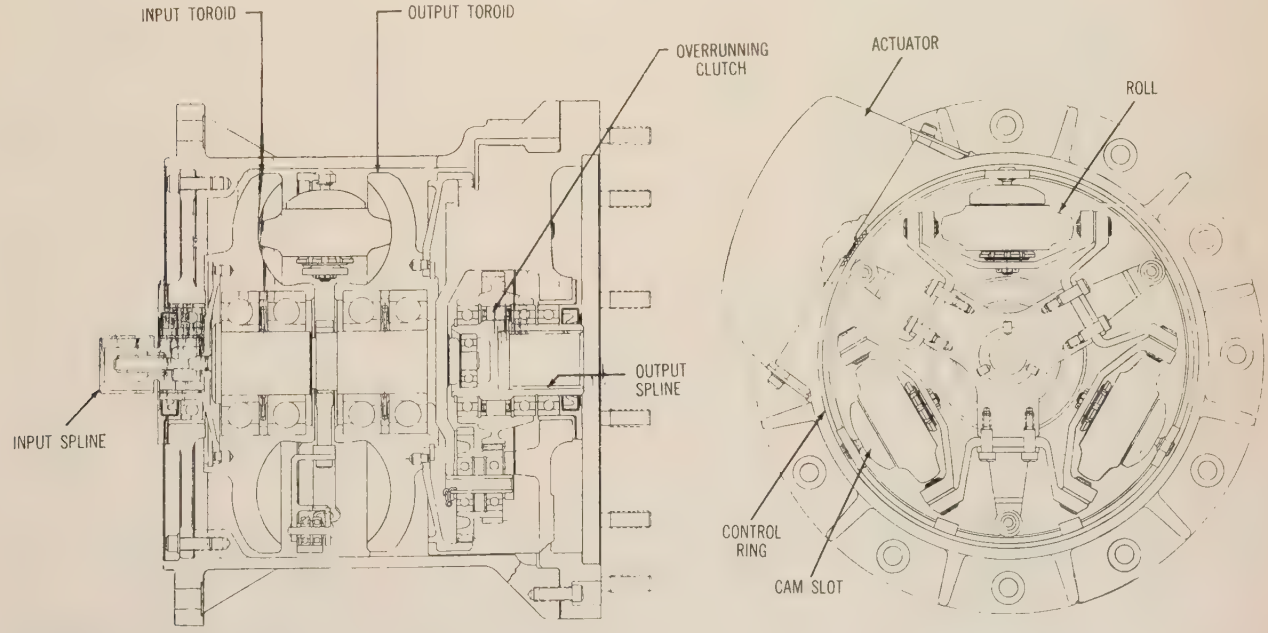
• *Transmission*—A variable ball-screw "thruster" that was added to the load bolt automatically adjusts the tension in the bolt as a function of load. Any overload torque rotates the ball-screw arrangement to tighten a nut on the end of the bolt and increase the squeeze force on the rolls. When the torque load is removed, the ball screw reverses and lightens the load. The drive can run under light roll loads during normal operation and yet carry overloads without slippage. The variable thrust should increase the service life of the toroid-roll assembly 6-8 times, Lycoming explains.

• *Primary Mechanical Control*—Here the important thing was to reduce the effects of temperature change on linkage components. Parts were designed and materials selected so that their thermal expansion is offset by the changes in the modulus of elasticity of the governor spring. Although the characteristics of parts change, the assembly remains basically unaffected.

Sync motors control frequency

• *Electric Trim Control*—Two synchronous motors driving a differential gear system are used for precise frequency control. One is run directly from the powered airborne electric system, the other from a constant-frequency oscillator-amplifier referenced to a tuning-fork frequency standard. Discriminating takes place in the differential gearing, whose output speed and direction depend on the difference in motor speed. Voltage affects torque only. In any event, the amplitude is limited to a level just high enough to overcome any slippage error. One problem remains—eliminating a slight frequency error of 0.5 per cent that crops up between 450 and 600 deg F.

• *Automatic Paralleling*—This involves getting two or more alternators (their drives) on the frequency and in phase before closing the paralleling contactor. A common tuning-fork reference is used to circumvent the danger of closing in on a beat frequency. The paralleling relay is closed by a phase detector. Off-frequency ac components are filtered out by an RC circuit. Write in No. 60 on Reader Service Card for more information.—End



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MINIATURE SIZE

9 16- by 2-5/16-in. torch head permits welding in hard-to-reach areas as small as 3 in. in diameter. Total torch length is under 7 inches.

3.3-OZ. FEATHERWEIGHT

Selected materials, such as glass fiber reinforced phenolic plastic, save weight without sacrificing strength. Torch (with short cap) weighs only 3.3 ounces.

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Capacity —
200 amp. AC or DC, continuous duty cycle;
225 amp. AC or DC, reduced duty cycle

Weight —
with short cap: 3.3 oz.*
with medium cap: 3.5 oz.
with long cap: 3.6 oz.

Length overall — 6⅞ in.

Length of Torch Head —
with short cap: 2-19/64 in.*
with medium cap: 3-9/32 in.
with long cap: 7-5/16 in.

Maximum Handle Diameter — ¾ in.

Maximum Head Diameter — 9/16 in.

Service Lines — 12½ or 25 ft.

*Torch is supplied with medium cap for 3-in. electrodes. Short cap for 2-in. electrodes and long cap for 7-in. electrodes are available as accessories.

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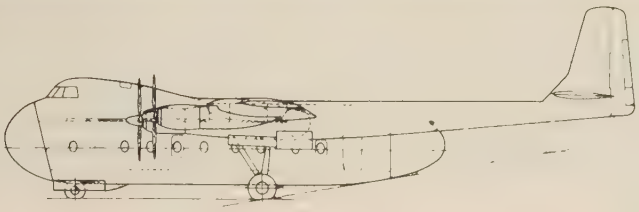
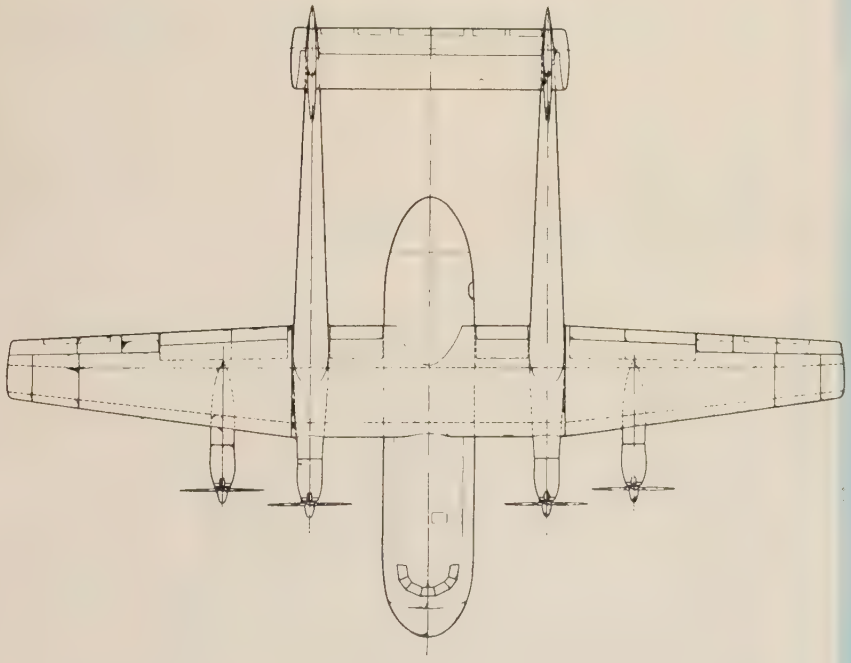
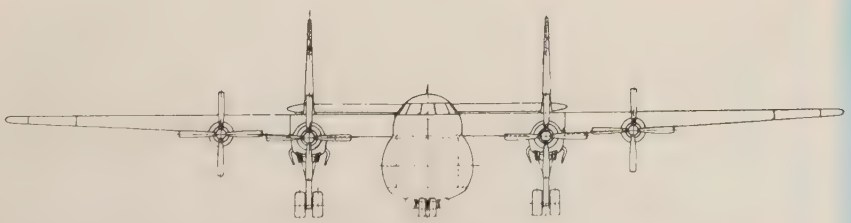
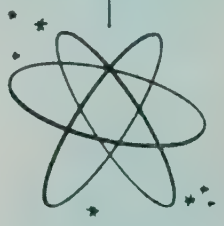




Wing span.....115 ft
Length .....86 ft 9 in.
Height .....27 ft
Cargo floor area.....426 sq ft
Tailplane span .....38 ft 6 in.



design progress



by Randolph Hawthorne,
Editor

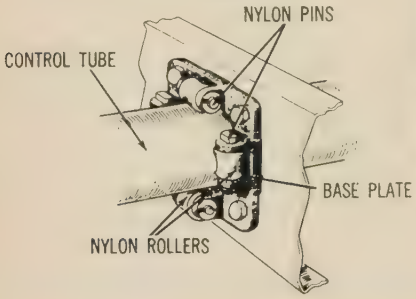
Argosy features two loading doors

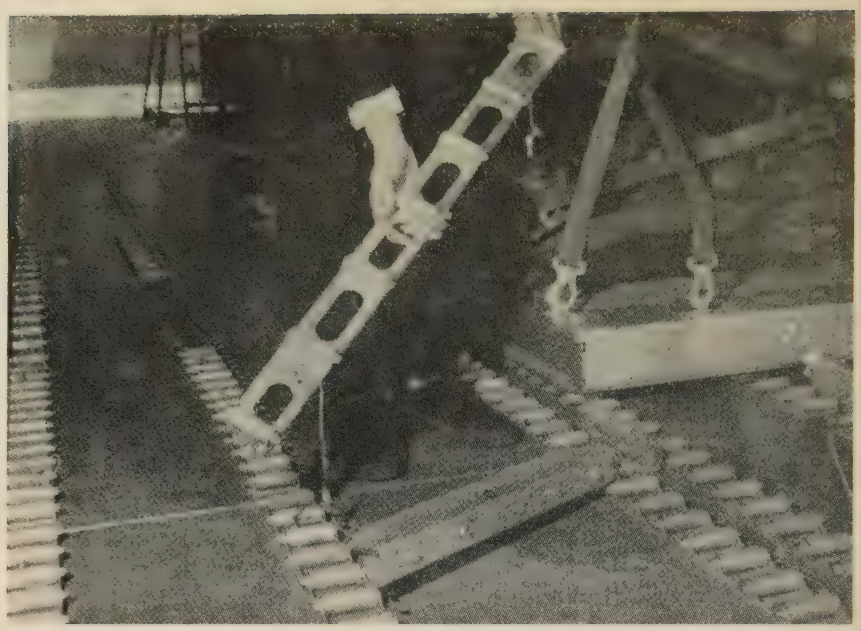
THE ARGOSY Freightercoach is unique among turboprop transports—it has fore and aft loading doors. Its cargo handling equipment also was developed to exploit this feature to the full. Powered by four Rolls-Royce R.Da7/2 Darts, the plane has payload range characteristics that allow for 20,000 lb over 1600 miles (no reserves). Designed and built by Sir W. G. Armstrong Whitworth Aircraft Ltd., Baginton, Coventry, England, the Argosy also comes in the A.W. 670 Air Ferry version, carrying six cars and 30 passengers, and the 671 Airbus, carrying up to 126 passengers on short sectors. A military version, the 660, with four Darts and a rear "beaver tail" door for supply dropping, has an integral loading ramp. Takeoff weight, 82,000 lb; average cruise speed, 276 mph (at 13,600 rpm) or 296 mph (at 14,000 rpm); takeoff field length (sea level, ISAC), 4050 ft. Circle No. 66 on Reader Service Card for more information.

more on next page

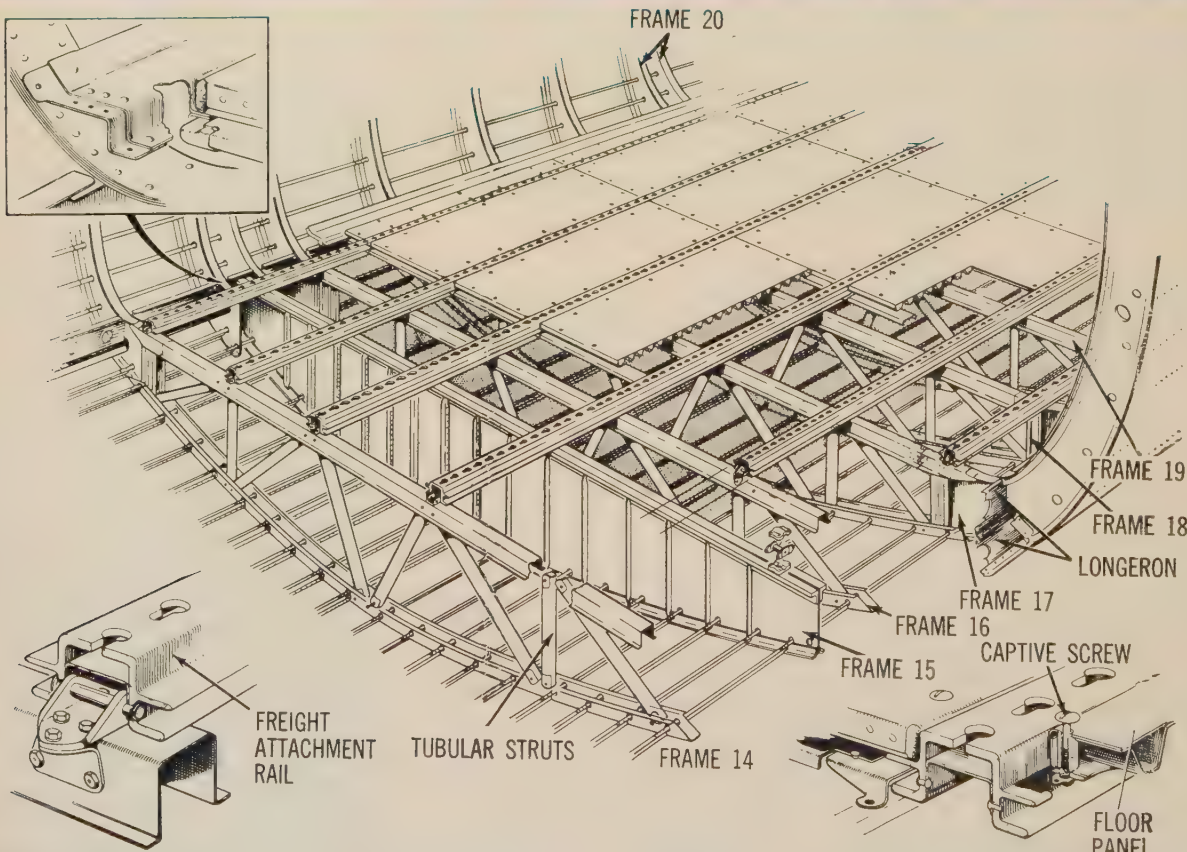
design progress

ROLLER bearing assembly. Roller assemblies are fitted to support and guide control tubes. Light alloy mountings have four pairs of lugs set at right angles to base plate, receiving rollers, and retaining pins.

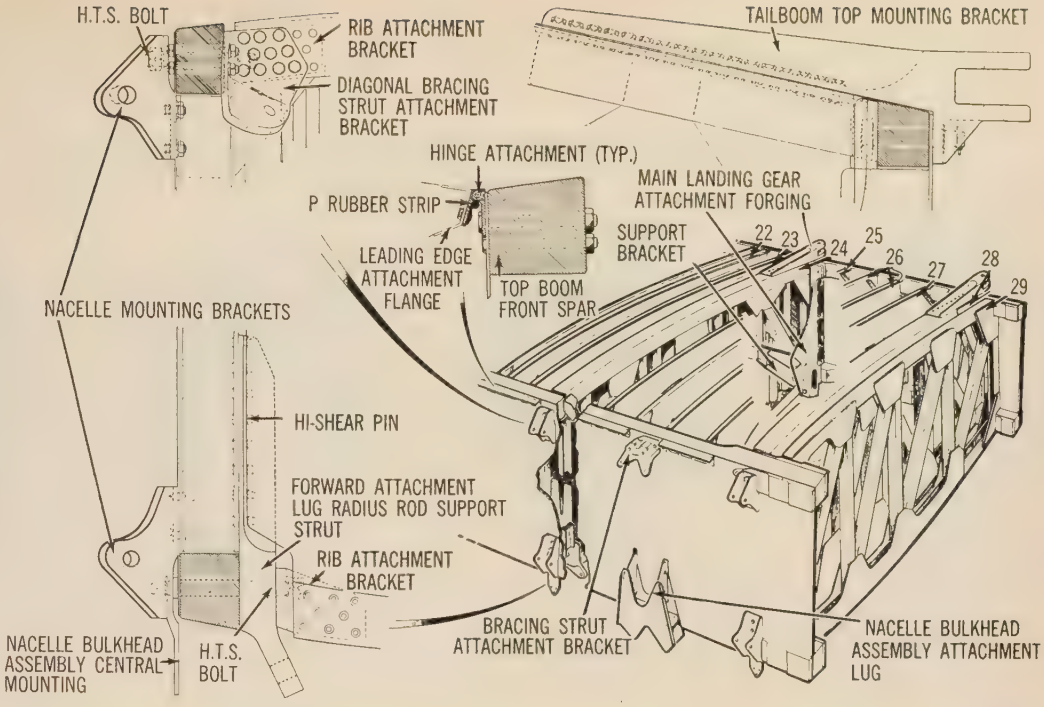




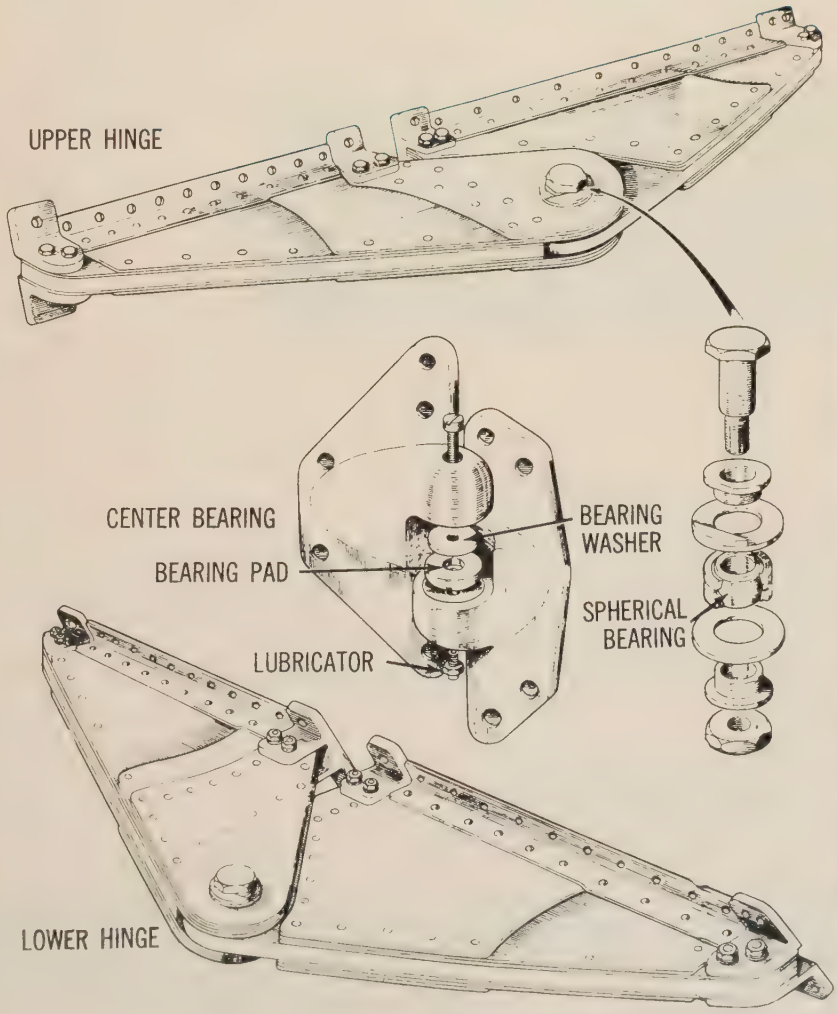
ADAPTABLE DESIGN of pallet system features roller conveyors. Here a pallet is anchored, while in foreground one of the roller units is being removed from the floor by means of pip pins.



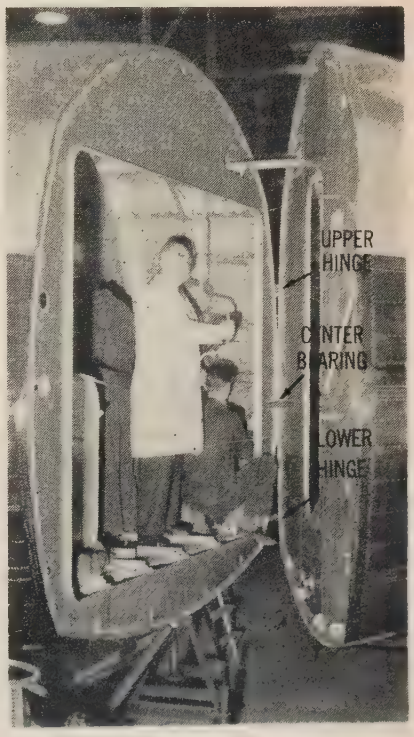
UNDERFLOOR structure (at center wing section area). Frames, built up generally as channel sections beneath floor and as I-sections above it, are attached to skin. Stringers are built in as intercostals, have boom continuity through frame finger straps and a stringer inner boom channel member. Fretting is reduced on parts subjected to repeated loadings, such as pins, bushes, and bolted joints, by molybdenum disulphide. Duralac or Celloseal acts as anti-fretting agent in riveted assemblies. All parts are fully protected against corrosion. Redux bonding reinforcements around heavily loaded areas throughout the fuselage keep stress levels low. All of fuselage, except nosewheel well, is pressurized.



WING CENTER SECTION details. Wing is a cantilever type mounted on top of the fuselage. It is in five main portions: center (shown here), intermediate, and outer. Each part is of twin spar mass boom construction.



HINGES and center bearing of the rear cargo door (left). Door and fuselage members of each hinge comprise a substantial bracket plate sandwiched between laminated reinforcing plates. The hinge swivels on spherical bearings. The center bearing houses a steel bearing pad in a cup recess in a fuselage member and a steel bearing washer between hinge members.



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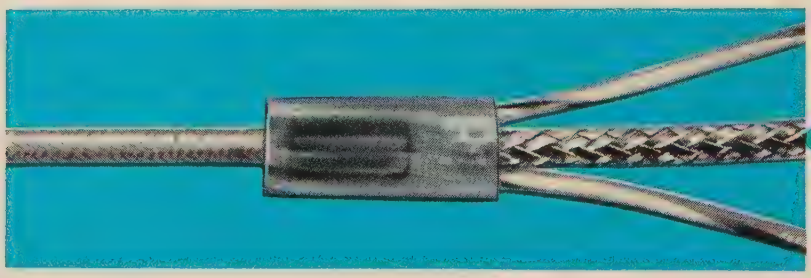

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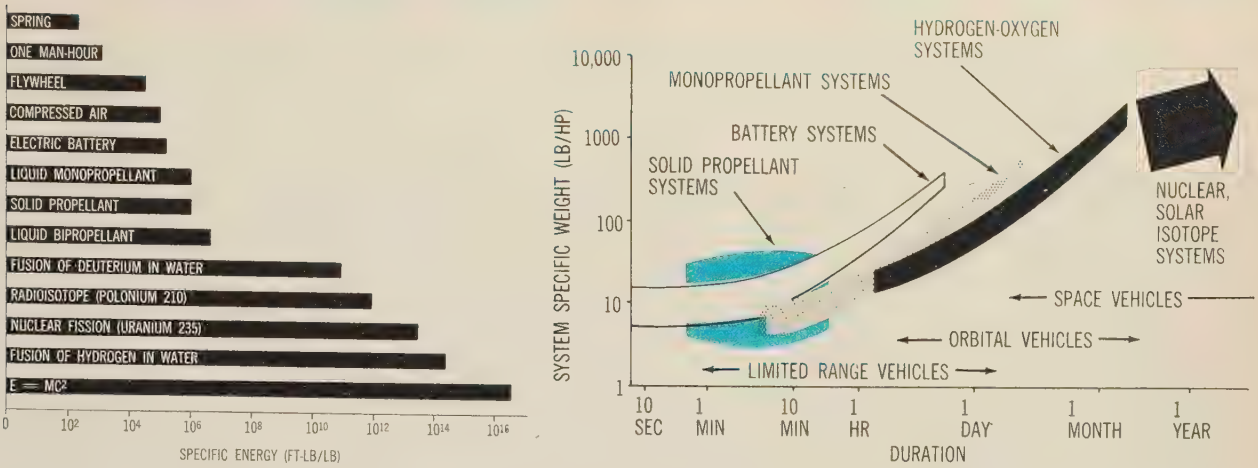

THEORETICAL specific energies of power sources for spacecraft APU systems (left) and specific weights of spacecraft APU systems vs duration (right). Nuclear, radioisotope, and solar systems are best for long durations.

Solar and nuclear APUs

coming up for space missions

In space flight, environmental control and secondary power will be more important than ever before—the X-15, for instance, could still land if its engines conked out, but its pilot would be a dead duck if all the APUs went on the blink.

by W. L. Burriss, Senior Preliminary Design Engineer, AiResearch Mfg. Div., The Garrett Corp *

THE main job of environmental control in any manned spacecraft will be the support of human life. The composition, temperature, and pressure of the gaseous medium in the crew compartment will have to be closely controlled to keep them from exceeding the narrow limits of human tolerance.

The environmental control system (ECS) also will have to provide the proper environment for the vehicle's various subsystems. Typical operating temperatures will range from cryogenic levels for infrared detectors to 70 deg F for manned compartments, 300 deg F for unmanned equipment compartments, and 2000 deg F on the skin during re-entry.

The equipment heat load of a spacecraft will be rep-

* AiResearch Mfg. Co., The Garrett Corp., 9851-9951 Sepulveda Blvd., Los Angeles 5, California. The author wishes to acknowledge the help of Mr. Ken Tangand and Mr. Hal Stavek in preparing the illustrations.

more on page 66

New Concepts for the Space Age
Mark 15 Years of Progress by MARQUARDT

When founded in 1944, Marquardt was an organization devoted exclusively to research and development of the ramjet propulsion principle. Today, in its fifteenth year, the Corporation employs more than 5,000 in the creation and exploration of new concepts for the space age. Marquardt is now diversified, operating in five basic areas—all primarily related to the search for earlier and ever more effective solutions to space-age problems.

NEW CONCEPTS IN AIR-SPACE RESEARCH spring from ASTRO—Marquardt's Air-Space Travel Research Organization—where studies of an ionic rocket capable of powering future space vehicles are in progress. Other imaginative ASTRO studies span a broad spectrum including high-energy fuels, exotic materials, nuclear powerplants, advanced optics, cryogenics, space medicine, communications and guidance.

NEW CONCEPTS IN POWER SYSTEMS are in the making at Marquardt's Power Systems Group. Within the Group, Propulsion Division is engaged in continuing studies of a Hyperjet (rocket-ramjet) configuration capable of lifting future satellites from launch pad to upper atmosphere. Controls and Accessories Division is currently developing attitude controls for reconnaissance satellites, while Test Division is capable of ground-testing space-age hardware.

NEW CONCEPTS IN MANUFACTURING are typified by the first-of-its-kind Hufford Spin-Forge at Marquardt's Ogden Division. This 250-ton machine will contribute advances in space-age metal working state-of-the-art, while augmenting the Division's production of supersonic ramjet engines for the Boeing Bomarc IM-99.

NEW CONCEPTS IN SPACE-AGE TRAINING are an important product of Marquardt's Pomona Division—creators of a unique system which realistically simulates a 4,000 mile mission on an 8-foot map. The system will ground-train air and spacemen without risk and at great savings in cost.

NEW CONCEPTS IN RESEARCH ROCKETRY and instrumentation come from Cooper Development Corporation, a Marquardt subsidiary. Cooper has contributed to programs including Explorer and Sunflare projects, and Falling Sphere—is now at work on Project Mercury.

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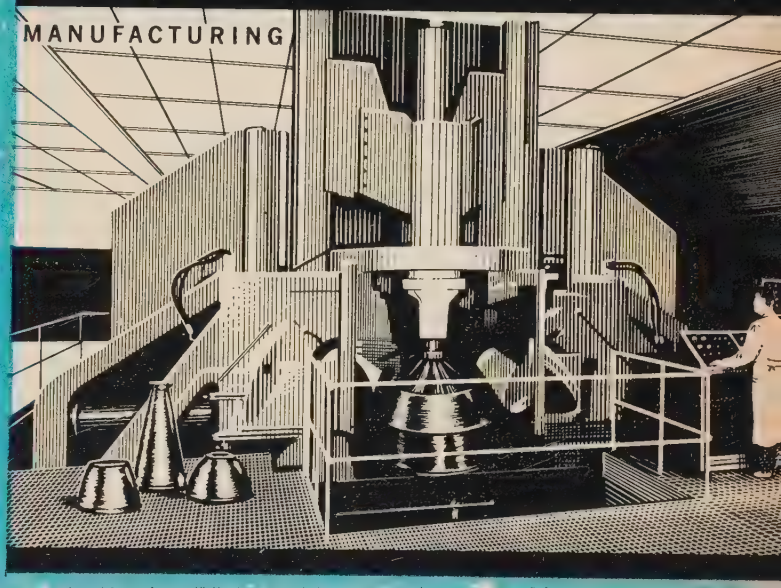

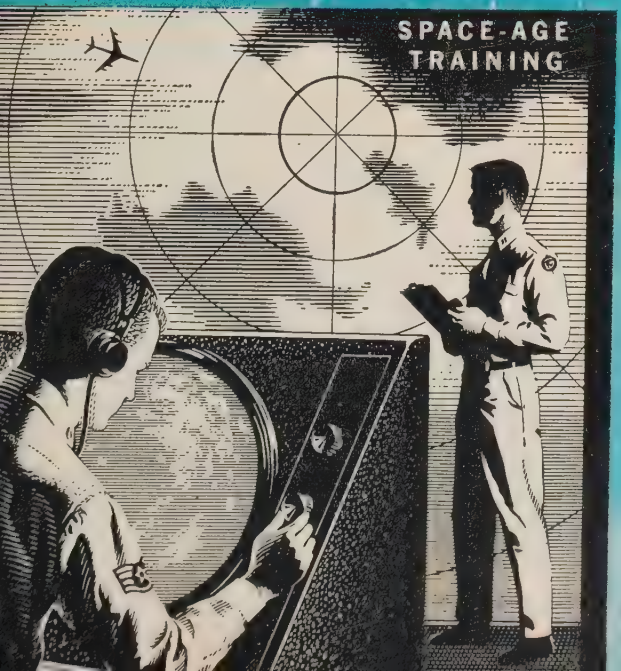

Engineers and scientists capable of making contributions in these and related areas are invited to write The Marquardt Corporation, Corporate Offices, 16555 Saticoy Street, Van Nuys, California; or

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resented mostly by the electric power consumption — the secondary power requirement in space probably will be almost entirely electric. The ratio of cooling load to secondary power requirements will run 1.1 to 1.5 for most missions. The two basic design features of the ECS are the heat sink and the supply of pressurizing gas for the manned compartment. On short missions (as on the X-15), the cabin can be pressurized from a liquid nitrogen supply that also serves as an expendable evaporant heat sink. The pilot would use a one-pass breathing supply.

For longer durations, a more efficient heat sink will be needed—possibly an expendable evaporant with high thermal capacity (water or ammonia) or the secondary power system's fuel. The cabin will be pressurized with air, so that the pilot's pressure suit faceplate normally will be open. Enough air will be dumped overboard to keep carbon dioxide and odor from building dangerously in the cabin. For durations of more than two days, we will have to conserve the air by passing it through absorbers to remove CO_2, water vapor, and odors.

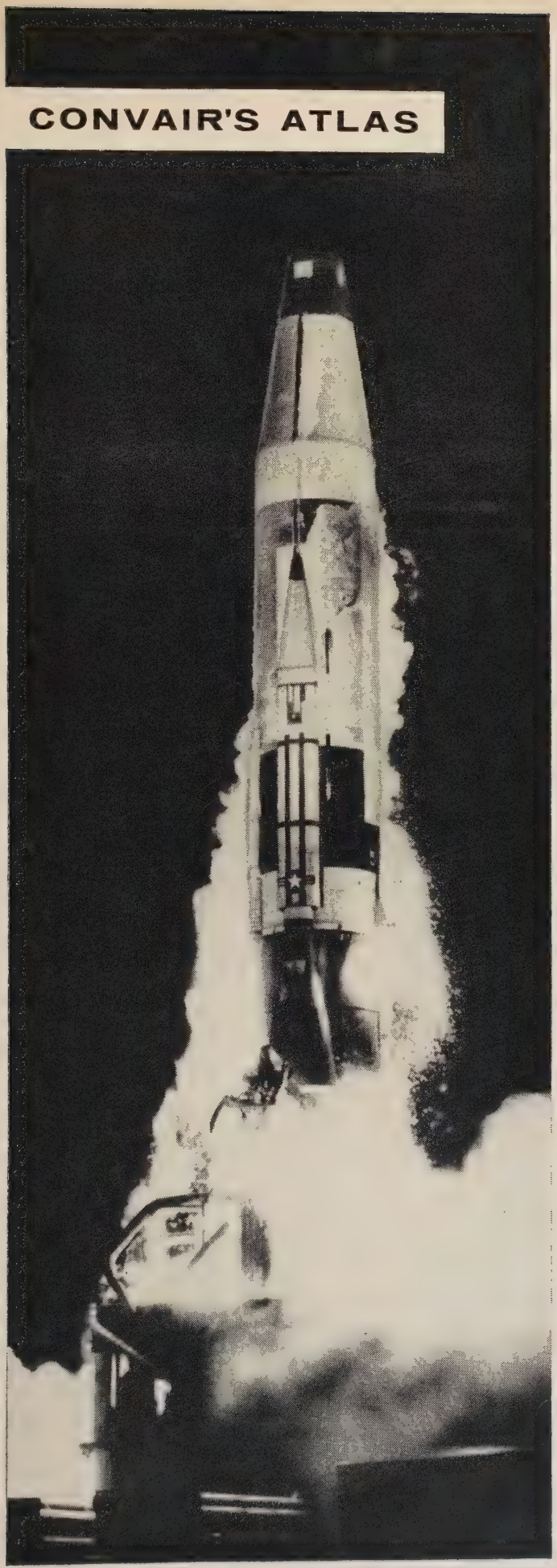
Hermetic cabins will be required

For durations of several months, hermetically sealed cabins will be needed. Cooling will be provided by mechanically driven vapor-cycle systems or by thermoelectric devices. A radiative heat sink will be used, possibly the same as that used by the secondary power system. Oxygen will have to be reclaimed from CO_2 by photosynthesis or the direct decomposing action of ultraviolet radiation. On extremely long missions for which resupply is impossible, biological or photochemical systems will have to generate food from waste products.

The *Table* compares the evaporative performance of several fluids (assuming the gases can be heated to 300 deg F). Some of these fluids can be used effectively as working fluids for the secondary power systems after they have done their job as heat sinks for the ECS.

To get high performance out of a gas turbine APU, the energy level of the working fluid should be raised to the maximum allowed by the turbine design. Practically this requires a turbine inlet tempera-

more on page 68



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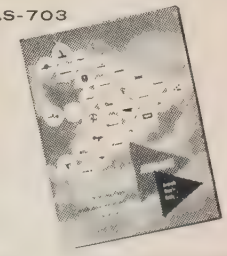

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ture of 1800 deg F. This heat level can be produced by the reaction in a monopropellant or bipropellant gas generator or by an external heat source.

Total secondary power needs will run from less than one to over 20 kw. The choice of the energy source for the secondary power system will be largely a function of the mission duration. Energy sources likely to be used in spacecraft include chemical fuels, solar energy, radio isotopes, and nuclear fission reactors.

Chemical energy can be used by direct conversion into electric energy in batteries and fuel cells or it can be used in heat engines as bipropellants or monopropellants. The *Table* shows that hydrogen has outstanding properties both as a heat sink for the ECS and as a working fluid for a gas turbine APU. It would seem to be a good idea, therefore, to integrate the two systems by using the APU fuel as the ECS heat sink.

Tough tankage problems with liquid H

The *Bar Graph* shows specific propellant consumption (spc) of 0.9 lb/bhp-hr for hydrogen at 35 per cent cycle efficiency. Even if the hydrogen heated to no more than 100 deg F, an spc of 3.6 lb/bhp-hr is attained. However, liquid hydrogen has a very low boiling point (—424 deg F at 14.7 psia) and a very low density (4.4 lb/cu ft), which will lead to very tough tankage problems—especially for the longer durations, when it is important to keep down evaporation losses.

Batteries appear to be limited to short duration, low power application and to cases in which quick delivery is more important than high performance. Fuel cells have a high cycle efficiency. They also give spc's of less than one lb/bhp-hr. At present, however, they weigh a lot. Considerable improvement is expected on this score. Fuel cells may be used to advantage in very low power output, long time applications, when little or none of the fuel is to be used as a coolant.

Heat energy from solar radiation, isotopes, or a nuclear fission reactor may be directly converted into electricity by photovoltaic cells, thermopiles, or thermionic devices. It may also be converted

more on page 72

HOW SAC's "HOUND DOG" SCENTS ITS TARGET

The crew of the B-52G starts up the jet engine of the sharp-nosed GAM-77 Hound Dog missile hung under its wing... gives its inertial autonavigator the location of the target.

On a "for-real" mission, the Hound Dog would leap toward its target at supersonic speed—very likely a ground-defense center hundreds of miles away. Its guidance system can't be jammed... can't be decoyed.

Purpose of the GAM-77 air-to-ground jet-powered guided missile is to increase the striking power of Boeing's B-52. Sling a pair of Hound Dogs under the wings of the new B-52G—and you have what amounts to a brand-new weapon system.

The GAM-77 program was started in August, 1957. The missile has been put into accelerated development. It already is in its early flight test phase... will be deployed by 1960.

Weapon system contractor: the Missile Division of North American Aviation.

MISSILE DIVISION NORTH AMERICAN AVIATION, INC., DOWNEY, CALIFORNIA

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This is our R. L. Lillestrand, Project Engineer. Here he examines a model of his Stellar Aberrascope, a multiple star tracking device which is expected to provide the measurement of space vehicle velocities to accuracies of the order of 100 feet per second. The Aberrascope is designed so that precise alignment of the star trackers is not necessary. His investigations could have a bearing on self-contained guidance systems used in future space vehicles.

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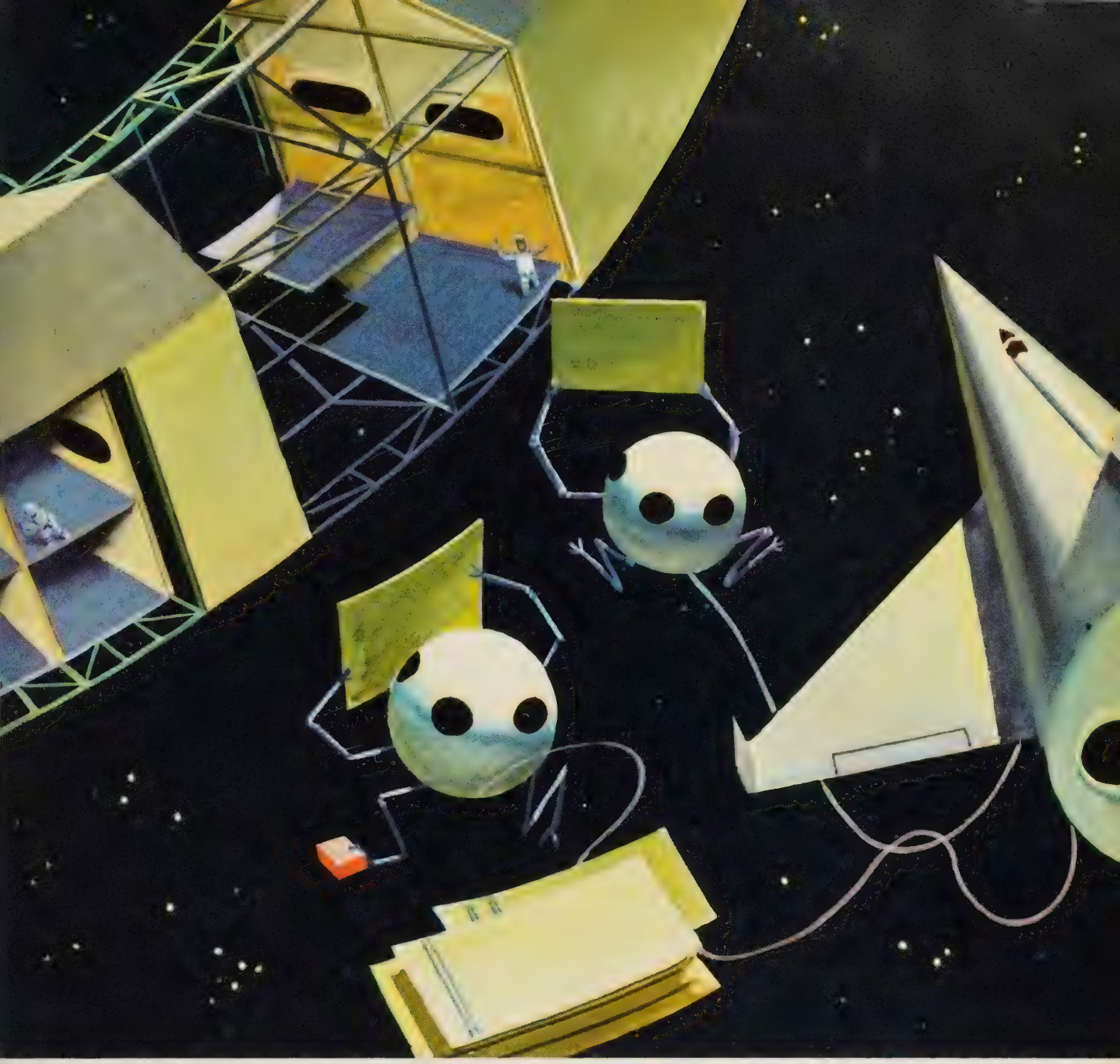
Development of a space vehicle guidance system which may one day be a factor in sending manned U.S. space stations into orbit around the earth is just one problem being attacked at the Mechanical Division of General Mills. In research, engineering and manufacturing, we are finding solutions to many problems that have application in the space age.

Our research activities cover broad areas in physics, chemistry, mechanics, electronics and mathematics. Some of the studies representative of these activities are: ions in vacuum, deuterium sputtering, dust erosion, magnetic materials, stress measurements, surface friction and phenomena, trajectory data and infrared surveillance.

In our engineering department, current projects include: airborne early warning systems, micro wave radar test equipment, antennas and pedestals, infrared and optics, inertial



assembling a space station . . . illustration from a book written for General Mills by Willy Ley.

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Heat Sink & Working Fluid Performance

	Density at Boiling Point (lb/cu ft)	Normal Boiling Point (deg F)	Latent Heat (btu/lb)	Total Thermal Capacity (btu/lb)[1]	Theoretical Expansion Work (btu/lb)[2]	Specific Propellant Consumption (lb/bhp-hr)[3]	Ratio of Thermal Capacity to Work Output (btu)[3]
Water	59.7	212	970	1112	1130	6.4	2.82
Ammonia	42.6	—28	590	769	2450	3.0	0.90
Hydrazine[4]	58.5	236	550	577	1490	4.9	1.11
Ethylene oxide[4]	55.1	51	249	324	1420	5.1	0.65
Ethyl alcohol	45.7	173	361	416	2040	3.6	0.58
Nitrogen	50.5	—320	86	241	658	11.0	1.05
Oxygen	71.2	—297	92	223	606	12.0	1.05
Hydrogen	4.4	—424	196	2451	8400	0.9	0.85

(1) Heat from boiling point to 300 deg F. (2) At infinite pressure retro, 100 per cent expander efficiency, and 1800 deg F total inlet temperature. (3) 35 per cent thermal cycle efficiency used to calculate propellant consumption and work output. (4) Mono-propellants

into shaft power in a heat engine driving an electric generator. The heat engine would use a recirculating working fluid in either a Rankine or a Brayton cycle. The Rankine-cycle heat engine would be harder to develop, since it would involve condensing and evaporating a fluid under zero-gravity conditions.

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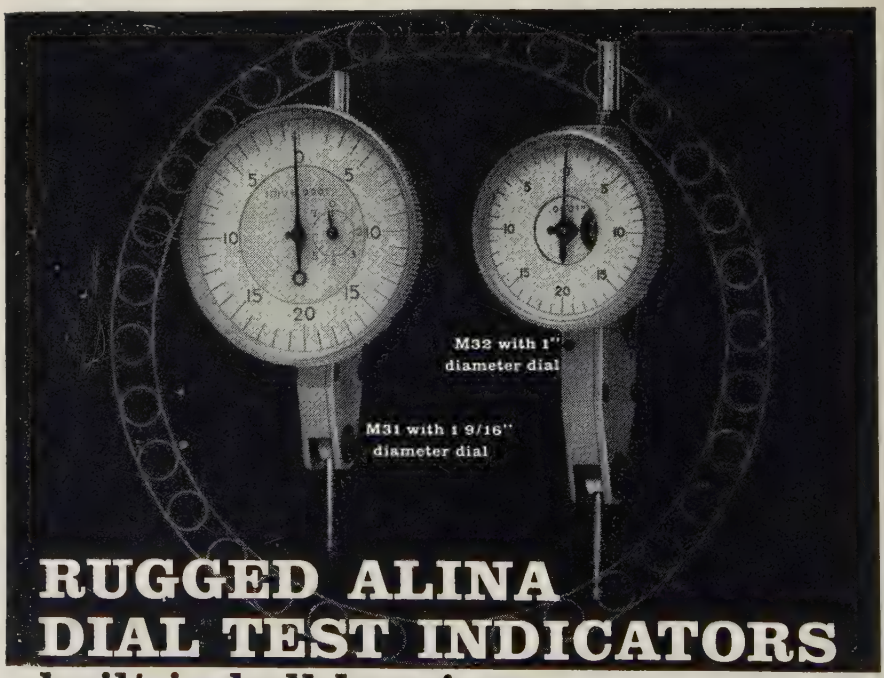

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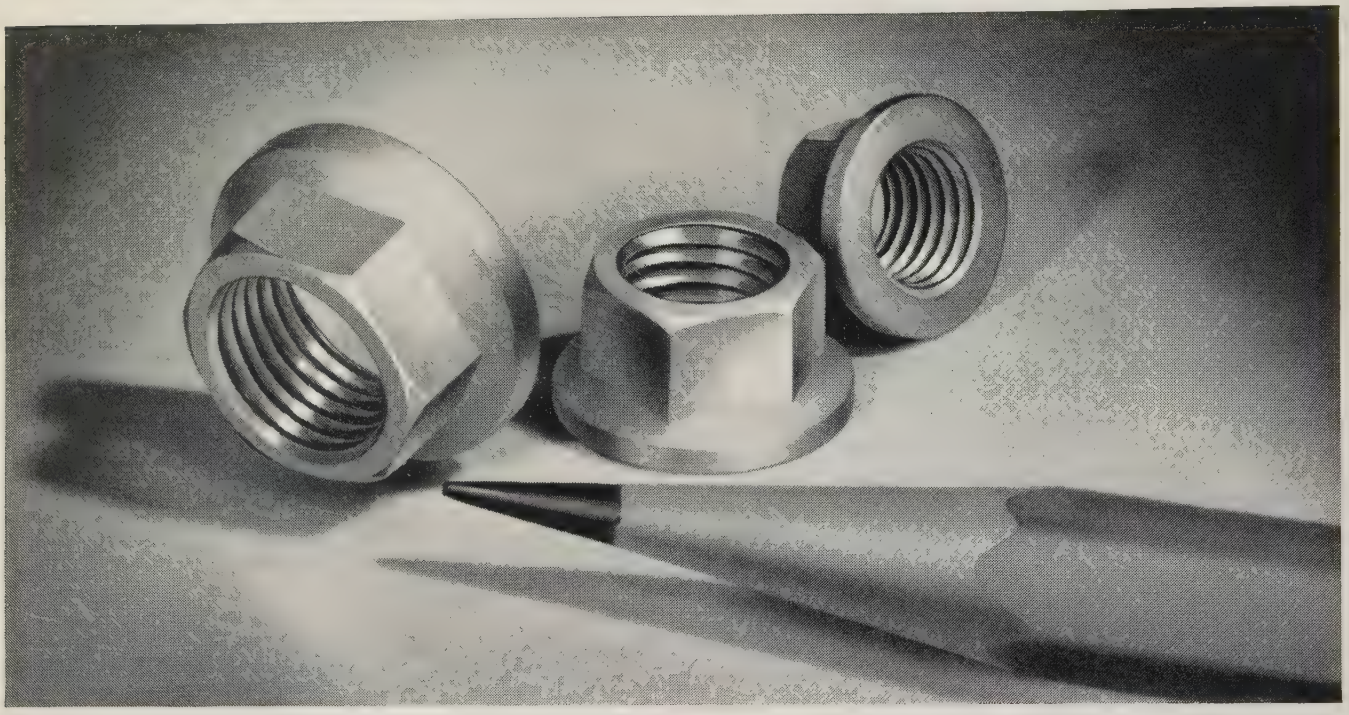
SPS FN-12 Featherweight locknut replaces NAS 679 and equivalents*—saves up to 72% in locknut weight



SPS FN-12 Series Featherweight locknut was the first to meet new NAS 1291 calling for a lighter weight replacement for NAS 679 sheet metal nuts. New forged featherweight offers major weight savings, superior performance, high reliability; also permits secondary weight reductions through use of narrower bolting flanges.

Here is one of the few nuts that meet new NAS 1291 standard calling for a lighter weight locknut interchangeable with NAS 679 sheet metal nuts. The new SPS FN-12 weighs 12-60% less than its NAS 679 counterparts . . . and 12-72% less than equivalent MS or AN types. Yet it sacrifices none of the static or dynamic properties of these larger, heavier nuts. It provides 160,000 psi tensile strength on a 180,000 psi bolt and gives greater bolt tension-tension fatigue strength than any other lightweight locknut tested.

The FN-12 saves weight in another way also. Because of its new configuration, it can be installed closer to vertical bulkheads than any other aircraft nut now in use. This allows a narrower bolting flange, with consequent reductions in aircraft weight.

You can specify FN-12 Series Featherweight locknuts in 11 sizes—#4 through 5/8 inch. All sizes are available for immediate delivery. From #4 to 5/16", FN-12 locknut prices are practically the same as NAS 679 locknuts. In the size range including 3/8" and above, prices are considerably lower.

For more information, write SPS—manufacturer of precision threaded fasteners and allied products in many metals, including titanium. Request Bulletin 2426.

ACTUAL WEIGHTS OF FN-12 AND COMPARABLE LOCKNUTS

All Weights Expressed as Pounds per 1000 Pieces

Size	FN-12	NAS 679†	% Weight Saved by FN-12	AN Series‡	% Weight Saved by FN-12
#4-40	0.4	0.8-1.0	50%-60%	1.3	69%
#6-32	0.7	1.3-1.7	50%-60%	2.5	72%
#8-32	1.2	2.1-2.5	43%-52%	4.2	71%
#10-32	1.5	2.5-2.8	40%-47%	4.6	67%
1/4-28	3.5	3.9-4.7	12%-26%	8.5	59%
5/16-24	5.4	6.4-7.2	16%-25%	11.8	54%
3/8-24	7.3	9.3	21%	19.5	63%
7/16-20	14.7	16.0	8%	22.6	35%
1/2-20	21.0	—	—	43.5	51%
9/16-18	24.4	—	—	71.5	66%
5/8-18	33.8	—	—	87.3	61%

†Range of four most commonly used sheet metal nuts of NAS 679 type
‡Range for AN 363, 364, 365

*MS 20364, MS 20365; NAS 1021, NAS 1022; AN 363, AN 364, AN 365 and AN Plain Nuts

AIRCRAFT / MISSILE Division SPS

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about 1000 lb/kw. They can operate on solar energy, requiring no fuel. Near Mars they perform about half as well as near the earth, so that they are less attractive for travel to the outer planets. They are best suited to missions requiring less than one kw output.

Lighter thermopiles and photovoltaic cells

Thermopiles weigh about 1500 lb/kw. However, the future weights of both photovoltaic cells and thermopiles should be down to less than 200 lb/kw. Thermionic converters may weigh even less.

An APU using a nuclear fission reactor will weigh between 1000 and 2000 lb for power outputs up to 20 kw. An APU using a radioisotope energy source may weigh somewhat less (around 500-1000 lb) for the same, since it needs less shielding.

The *Graph* compares the specific weights of a number of secondary power systems. As we've noted, nuclear, radioisotope, and solar (heat engine) power systems have high fixed weights that won't change significantly at durations up to a year or so. Systems of these types are best for durations of over 30 days.

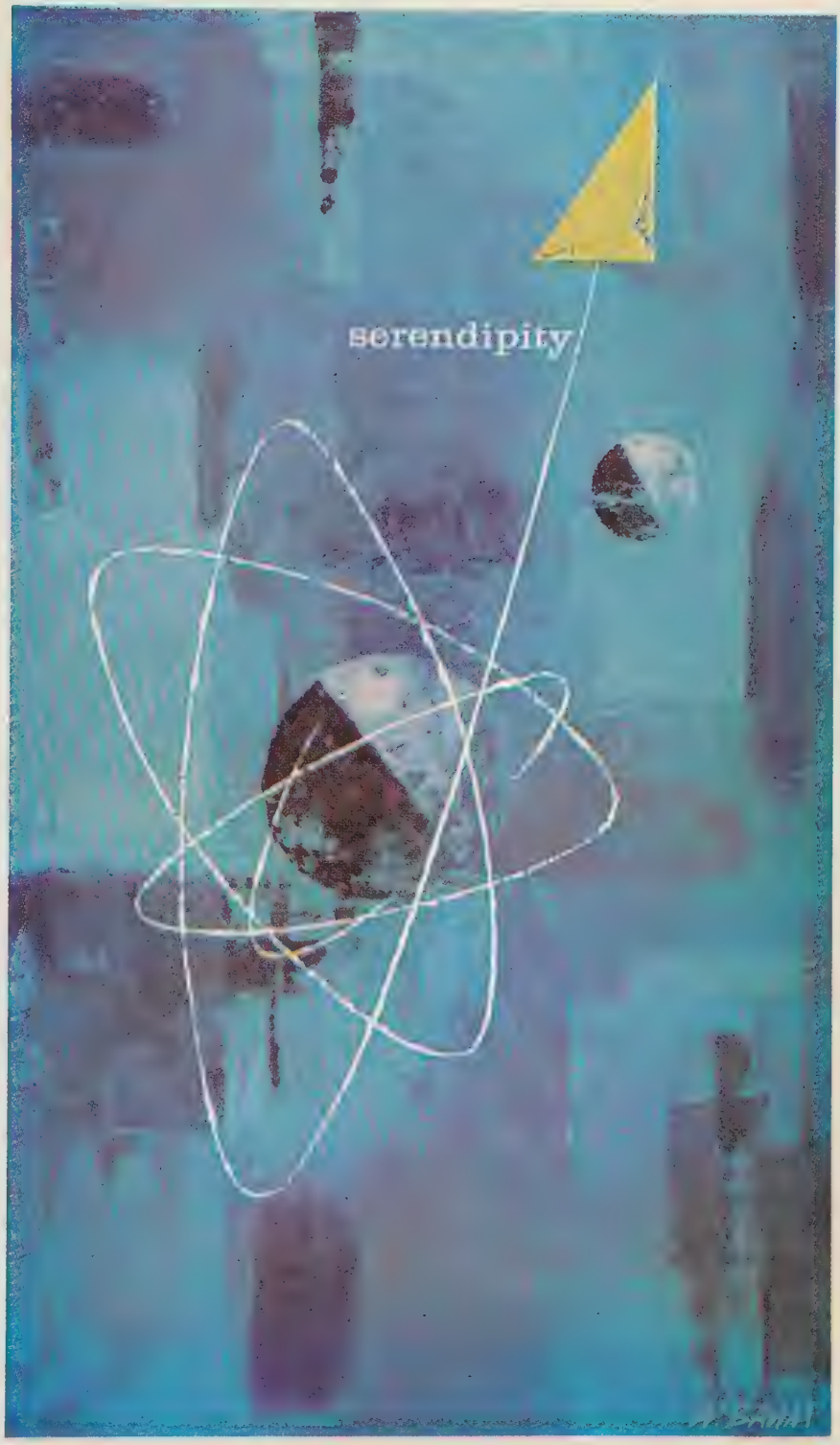
Strictly from the standpoint of secondary power alone, monopropellants have advantages for durations of up to one hour. For the requirements of both secondary power and environmental cooling, chemical fuel systems using fuel as the heat sink will be best for durations of over 30 days.

Secondary power may also have to be used for attitude control. Stored air and solid propellant rocket systems are best applied here for short duration tasks, such as alignment for re-entry or course correction.

Monopropellant rockets can be used to advantage on manned orbital re-entry vehicles that need considerable and precise control. Electric propulsion (by ionic, plasma, or magnetohydrodynamic systems) produces very high specific impulses (over 10,000 sec), but needs very large electric power supplies for low thrusts (over 100 kw for 1 lb of thrust). Obviously it is feasible only with nuclear energy sources.

Several probable trends in the design of ECS and secondary power systems can be continued:

more on page 77



exploring the fascinations of space *and applying the knowledge gained therefrom is one aspect of serendipital intellectuality which the truly creative talent finds at Martin-Denver. If you are seeking such an experience, and desire to participate in the most advanced thinking in space science, communicate immediately with N. M. Pagan, Dept. AA-5, The Martin Company, P.O. Box 179, Denver, Colorado.*

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- Solar cells will be used on small, uncooled satellites whose power requirement is less than one kw.
- Higher power needs for satellites and space stations (up to 100 kw) will be met by solar APUs (heat engines).
- Interplanetary vehicles will use nuclear APUs with ratings from 100 kw to over a megawatt.
- For medium-duration vehicles (60 minutes to 30 days), the use of integrated ECS and secondary power systems appears feasible, with the fuel doubling as a heat sink.—End

books

Polar Atmosphere Symposium (two volumes), edited by R. C. Sutcliffe (Part I) and K. Weekes (Part II). The papers presented at the July 2-8, 1956 AGARD meeting, held in Oslo, Norway, on the current state of scientific knowledge about polar atmospheres and their effect on conditions in other latitudes have been compiled in this set. Pergamon Press, 122 E. 55th St., New York 22, N.Y. Vol. 1, $12; Vol. 2, $10.50.

Aircraft Engines of the World, 1958-59, by Paul H. Wilkinson. Performance data and specifications are given for gas turbine, ramjet, rocketjets and reciprocating engines. Paul H. Wilkinson, 734 15th St., N.W., Washington 5, D.C.

Control System Components by J. E. Gibson & F. B. Tuteur. Some of the most commonly used components in feedback control systems are analyzed from a systems engineer's standpoint. McGraw-Hill Book Co., 330 W. 42nd St., New York 36, N.Y. $12.

Electricity in Aircraft, by F. G. Spreadbury. This book discusses some of the newer aspects of airborne power generation. Topics include ac and dc power generation, electrical ignition for turbine engines, rotary converters and inverters, etc. The Macmillan Co., 60 Fifth Ave., New York 11, N.Y. $8.

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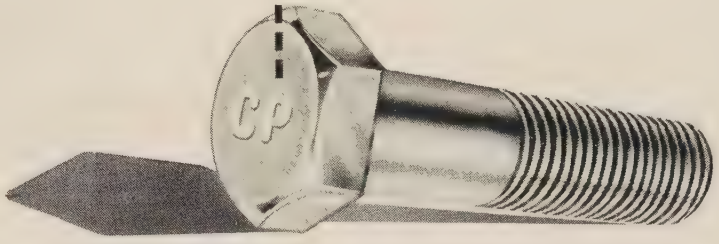

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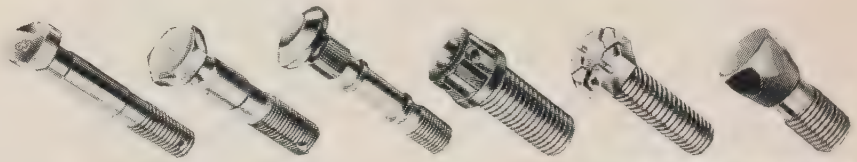

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Conference on Welding Engineering, arranged by A. L. Tarr. Reprint of the papers presented at Ft. Belvoir, Va., April 29-May 1, '57. Welding codes, materials, test methods and various specific applications, from bridges to aircraft, were among the topics discussed. Office of Technical Services, U.S. Dept. of Commerce, Washington 25, D.C. (Report PB 131739), $6.

Cleaning of Electronic Device Components and Materials. This covers the proceedings of an ASTM symposium held in Philadelphia, Pa., in Oct. 1958. Papers cover such topics as measuring and controlling dust, eliminating contaminants, use of ultrapure water, etc. American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa. $6.50.

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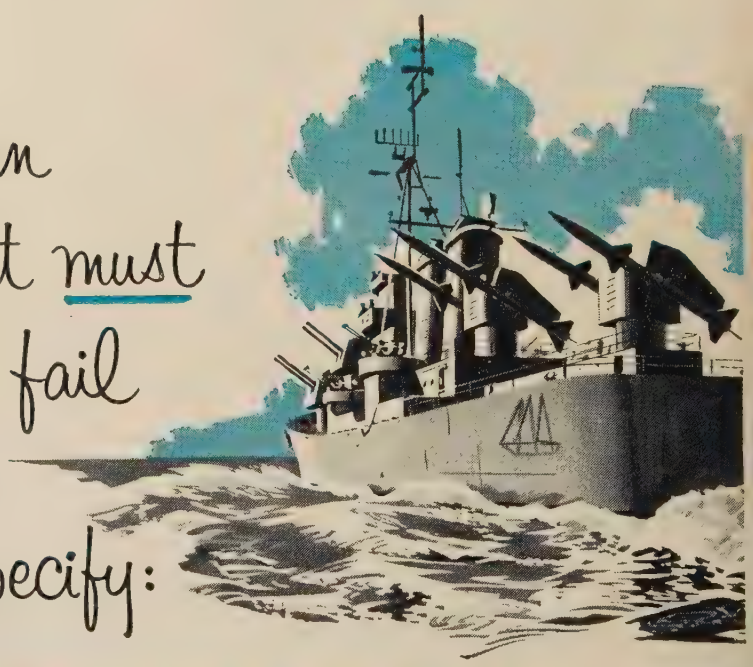

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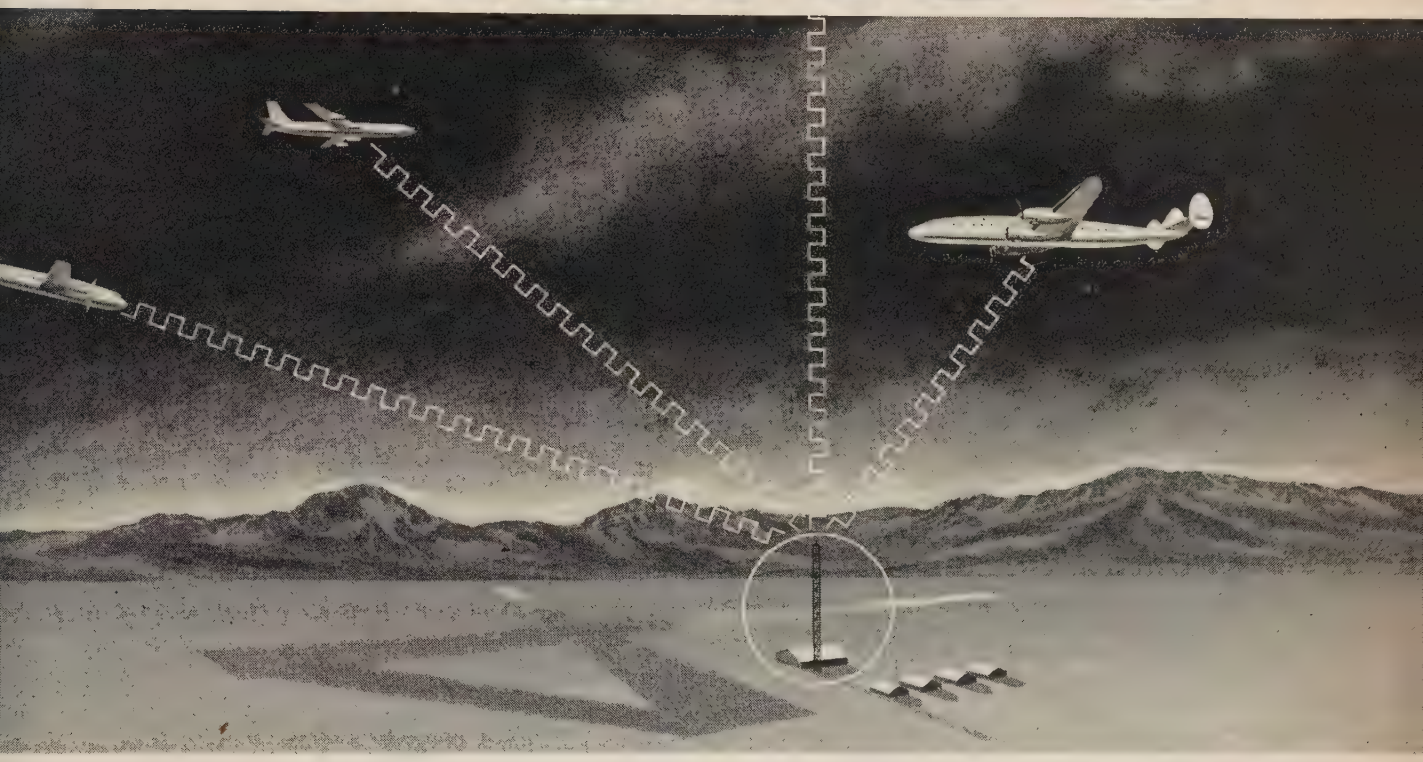
new wings for words

AGACS

pronounced "AJAX"



AGACS, Experimental Automatic Ground/Air/Ground Communication System is a new concept in Air Traffic Control Communications to meet the accelerated pace of increased air traffic. Primary objectives are efficient usage of frequency spectrum, added safety through increased reliability and reduced burden to pilot and controller, and adaptability to all classes of aircraft. AGACS provides compatibility with existing ground and airborne communication equipment, selective addressing of information, and a minimum number of frequency changes during flight. The system utilizes two-way time division data transfer over existing ground and air communication links to provide an automatic, mutual exchange of information. The airborne facilities display to the pilot the last significant Air/Ground and Ground/Air message quantities, while the controller may recall from central memory-storage equipment the last Air/Ground and Ground/Air message quantities for display. The AGACS program is still in the developmental stage. In August, 1959, RCA provided initial models of both airborne and ground equipments for the Bureau of Research and Development of the Federal Aviation Agency for extensive experimentation and flight tests.

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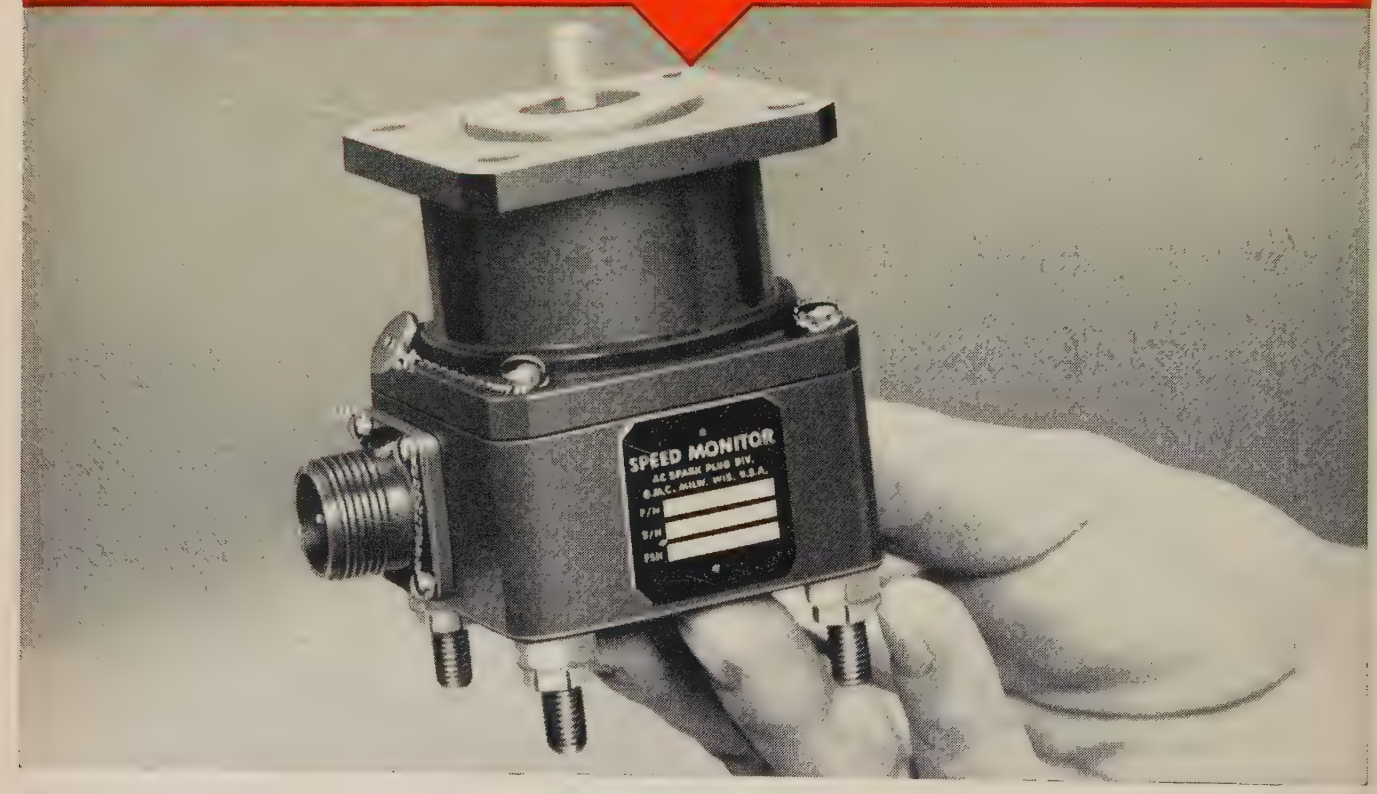

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If you have need for this superb automatic device, and wish more details about it, or AC Fuel Controls, contact the Director of Sales, **AC Spark Plug—the Electronics Division of General Motors, Milwaukee, Wisconsin.**

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Advanced welding

requires accurate fixturing

Welding has become a primary fastening method for high performance craft, replacing such old standbys as rivets and bolts in many areas of structural design. The key to good automatic welding in turn lies in the development of accurate fixturing devices.

by W. P. McGregor, Tool Development Engineer, Convair-Astronautics*

IN LESS than 25 years, the art of welding has progressed from the oxyacetylene torch and the bare electrode for arc welding on mild steel to the inert-gas tungsten-arc and submerged-arc methods used on today's missiles and spacecraft. The principal current welding processes include:

- inert-gas tungsten-arc welding on stainless steels and nonferrous metals in thicknesses varying from 0.001 in several inches;
- metal arc welding for mild steel (the most widely used type), with thicknesses varying from 0.09 to over 12 in. on some assemblies;
- submerged-arc welding for heavy gages o fstainless and mild steel;
- inert-gas metal-arc for heavy gages of ferrous and nonferrous metals;
- inert-gas arc spot welding on thin gages of stainless steel, titanium, copper, etc;
- stud welding of ferrous and nonferrous metals in stud sizes from ⅛ to 1¼ in. diameter;
- spot and seam resistance welding of stainless steels, aluminum, high nickel alloys, etc., in thicknesses from 0.001 to 0.5 in.;
- brazing and soldering, which are also considered to be welding methods, along with oxy-acetylene arc, and Heliarc cutting.

Fusion and resistance welding methods account for about 87 per cent of the welding done in the aerospace industry. It represents as much as 65 per cent or more of the fastening on today's advanced missiles and research vehicles. (Formerly, of course, such methods as riveting predominated). Even more welding will probably be required for future missiles and spacecraft. Ground support and handling equipment in particular

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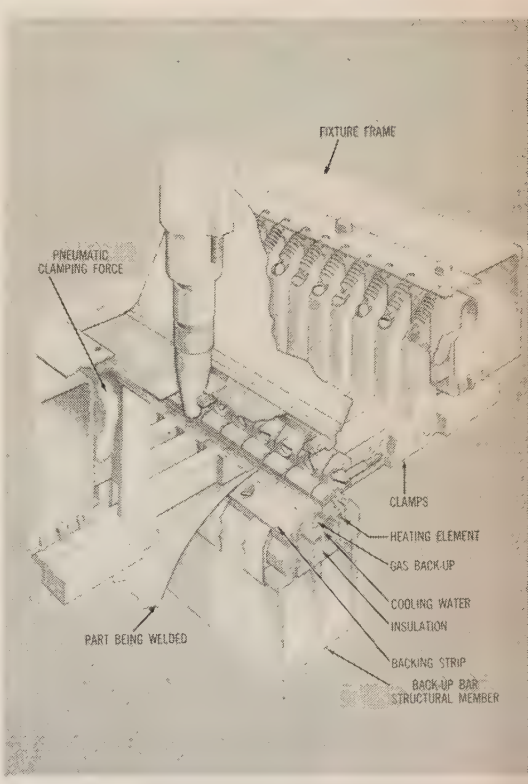
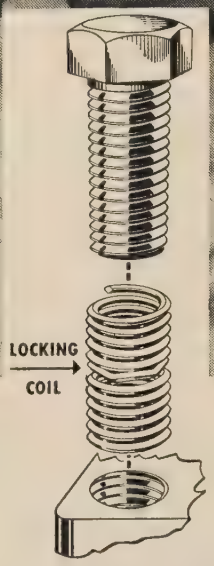


FIGURE 1: Cross-section of typical Heliarc weld fixture.

* Convair Div., General Dynamics Corp., San Diego 12, Calif.



Heli-Coil® Stainless Steel Screw-Lock Insert is easily wound into tapped hole in lightweight aluminum housing. Spring tension of the locking coil retains screw securely, meets military specifications for locking torque and vibration.

How Carrier Corporation Saves 40% in weight • 30% in assembly time ...with *HELI-COIL*® SCREW-LOCK INSERTS*

Use of aluminum lightens Carrier refrigeration system in Douglas DC-8 Jetliner

To reduce weight in the refrigeration system designed for air conditioning the giant Douglas DC-8 Jetliner, Carrier engineers used aluminum alloy compressor castings. To obtain maximum performance and reliability of threaded connections exposed to heat and vibration encountered at 600 mph, they selected the *Heli-Coil* stainless steel wire thread, *internal locking* Screw-LOCK Insert.

The results: design simplified, boss areas minimized, weight reduced as much as 40%, lock nuts and lock wiring eliminated. Now one man assembles the entire unit in 30% less time than before ... and danger of thread failure and screw loosening has ended!

Manufacturers in every field are relying on one-piece, stainless steel *Heli-Coil* Screw-LOCK Inserts to meet torque and vibration specs... protect threads against wear, stripping, galling and corrosion... save costs, space and weight. *Patented

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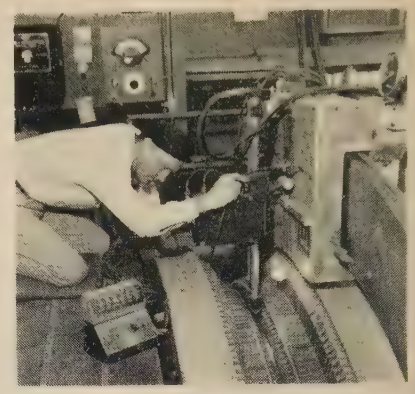

FIGURE 2: Heliarc weld fixture at Convair-Astronautics holds compound contour sections.

depends on the efficiency and economy of fabrication by welding.

Fixturing is a key element in today's automatic welding processes. As an example, *Figure 2* shows a fixture designed by the tooling department at Convair-Astronautics. It holds part of a double-contoured section for Heliarc welding. The side beam carriage has a constant speed and carries an automatic, voltage-controlled welding head. Welding is done at a 45-deg angle upgrade to a 45-deg angle downgrade with no backlash.

Figure 1 shows a cross-section of a typical heliarc fixture like the one in *Figure 2*. The rigid frame supports the clamps with minimum deflection. Pneumatic clamping applied by fire hoses equalizes the pressure over the full length of the back-up bar.

Spot weld gun reaches all part's areas

Figure 3 shows an Astronautics fixture for spot welding bracketry on missile component parts. The spot-weld gun moves up and down the arm, which rotates around the conical shaped part. In this way, all areas of the part remain accessible.

Figure 4 shows an Astronautics resistance-spot-weld fixture for attaching clips and bracketry on missile tank skins. It can attach clips, doublers, angles, intercostals, etc., on either single or double skins. The table rotates, turning the skin, and the C-gun moves up and down by hydraulically tele-

more on page 84

WITH ONLY MINUTES TO ACT

If America should be attacked . . . from bases around the world Strategic Air Command bombers, tankers and surface-to-surface missiles will rise to action. Minutes only will be available.

To integrate and control this assault requires accessibility and handling of a staggering volume of data. In the missile era, present methods of gathering and processing data will be inadequate. SAC is automating the system.

As systems manager, International Electric Corporation is developing and will turn over to SAC a world-wide electronic combat control system, an integrated complex of electronic subsystems. The system, employing digital techniques and equipment, will transmit, process and display information on a global basis . . . with only seconds involved.

Engineers whose interests lie in systems engineering, data processing and communications will find in this long-term project exceptional opportunity to exercise creative competence and individual initiative. For details of engineering assignments write B. J. Crawford, Director of Technical Staffing.

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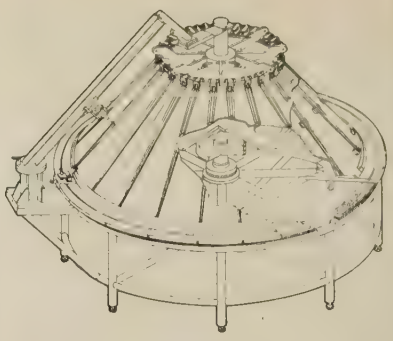


FIGURE 3: Stiffeners are attached to a cone in resistance spot weld fixture used on an Astronautics missile production line.

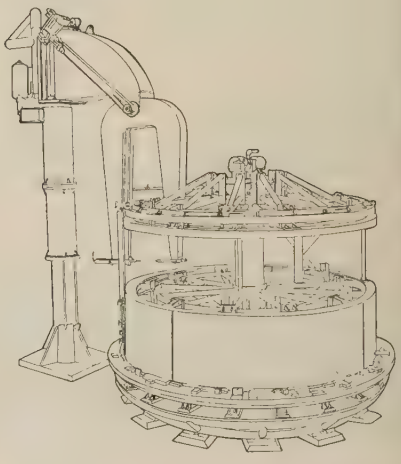


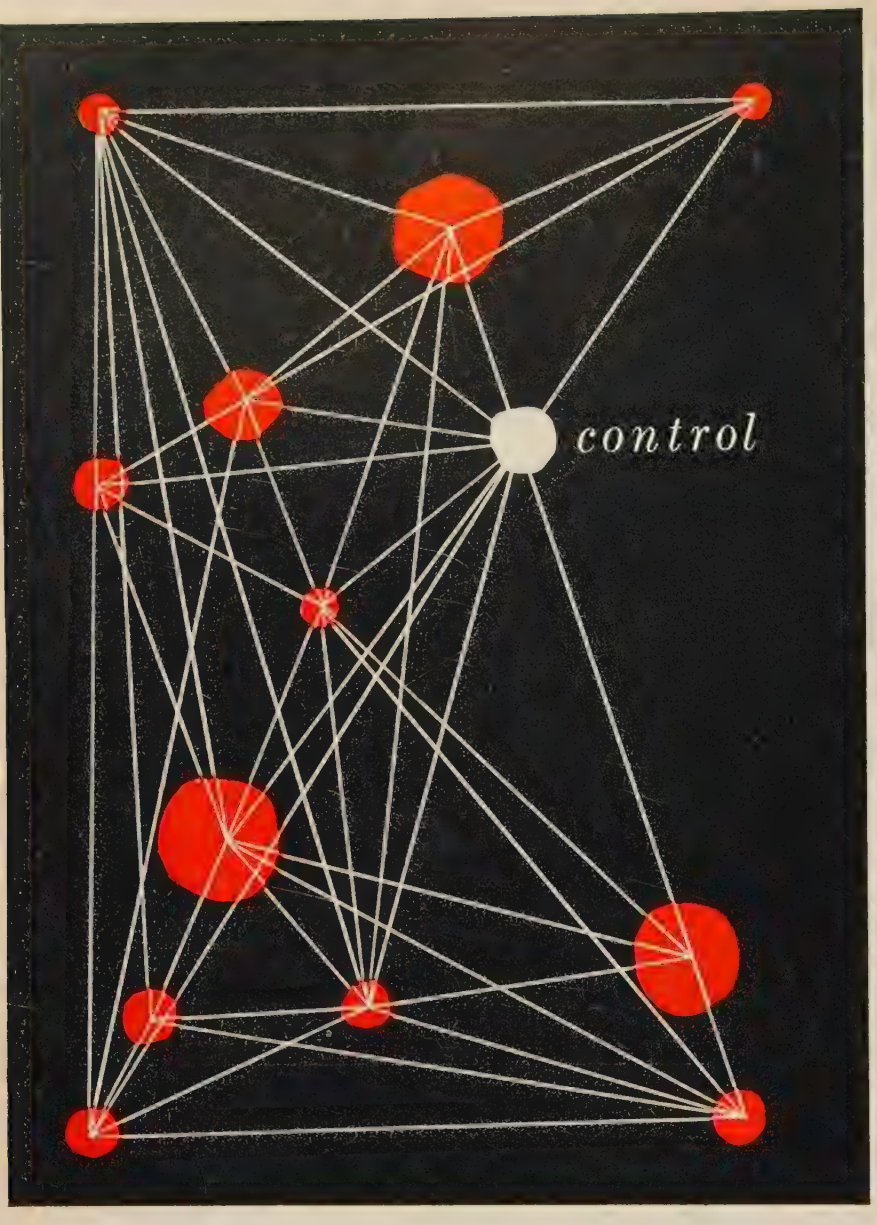
FIGURE 4: Resistance spot weld fixture for automatic welding of stiffeners to missile tank skins.

scoping the column, so that welds can be placed at any position on the skin subassemblies.

As we can see, fixturing has become as important a part of the welding process as the welding equipment itself. In fact, the trend seems to be toward fixturing equipment for aerospace welding that is as accurate as custom fixturing for machine tools.—End

A Correction

In the article "Microstructure Affects Steel Fatigue Strength" in the July 1959 issue, the graph on *page 90* was partially mislabeled. The ordinate of this graph actually shows the *transformed part* of the retained austenite. As published, the label of this ordinate implied that all retained austenite is transformed.



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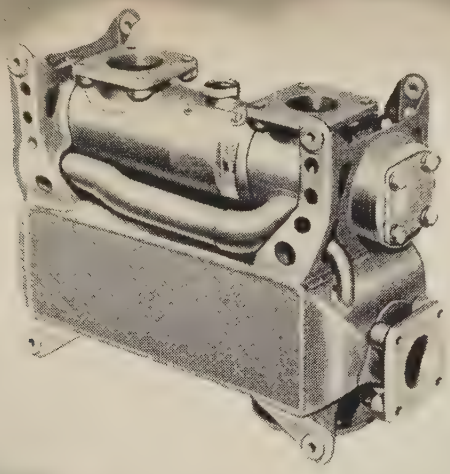

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SPECIFICATIONS

Fuel Side (MIL-F-5624A, JP-4)
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Fuel temp. out . . . +33°F
Fuel flow . . 10,500 lbs/hr

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Air flow . . . . 90 lbs/min
Control — Integral automatic modulating thermostatic power element type.

• AiResearch is now in quantity production of an extremely reliable engine bleed air fuel heater which prevents icing in the B-52 engine fuel system during flight. This unit utilizes a minimum of hot compressor bleed air automatically modulated to keep fuel temperature above 32°F. Heating the fuel in flight overcomes the icing problems resulting from the presence of a limited quantity of water in the airplane fuel system regardless of the source of such water contamination.

Efficient design and development capability made it possible for AiResearch to build an efficient lightweight bleed air fuel heater system on an expedited schedule of seven month's time from initial order to production delivery. AiResearch has been the world's largest and most experienced manufacturer of aircraft heat transfer systems for 20 years. Outstanding design and production facilities, supported by extensive laboratory and test equipment, enable AiResearch to quantity-produce fuel heaters of any configuration in minimum time while maintaining rigid quality controls.

In addition to the B-52 fuel heater, AiResearch is also producing several other types of plate and fin air-to-fuel as well as shell and tube oil-to-fuel heaters for both military and commercial aircraft applications. Your inquiries are invited.

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Systems, Packages and Components for: AIRCRAFT, MISSILE, ELECTRONIC, NUCLEAR AND INDUSTRIAL APPLICATIONS

Write in No. 34 on Reader Service Card at start of Product Preview Section

Corrosion-Fighting Titanium Sheet Paves Way for Honeycomb in Navy A3

Titanium metal's corrosion res
ance has enabled North Americ
Aviation designers to draw up
the stiffness and light weight
herent in honeycomb-core co
struction for the inlet guide ram
of the Navy's Mach 2 attack a
craft, the A3J Vigilante.

• Titanium metal, immune
salt water corrosion build-up, h
proved so effective in replaci
aluminum cover sheets and cha
nels that existing A3J aircraft w
be retrofitted with the new desig
The overall weight saving—in
fect a design bonus—is 22 percen

Installation of titanium in th
assembly is the latest step in t
continuing trend of designers
capitalize on titanium's uniq
combination of intrinsic prope
ties: low density (0.16 lb./cu. in
great strengths, outstanding corr
sion resistance, and ability to r
tain its properties under long-tim
exposure from −300°F up throug
intermediate temperature rang
Its effectiveness under conditio
of short-time exposure was seen
its use as the nose-cone tip of th
Vanguard where titanium wit
stood temperatures of 1500°F.

The A3J inlet ramps are mad
of flat, tapered titanium shee
adhesive-bonded to an aluminu
honeycomb core. Each assembly
about 5 ft. long, 2 ft. wide, an
3 in. thick, with 16,000 holes drille
through the skin, to control a
flow to the engine. Because a larg
volume of air flows through thes
holes, a small amount of corrosiv
product build-up would seriousl
impair the ramp's performance.

An integral part of the panel i
an I-beam-shaped titanium allo
rib which connects the ramp to it
actuator. This rib, machined b
North American from a Ti-6A1-4V

eat-treated forging, weighs about lb., and is riveted into the panel.

To take advantage of the corrosion resistance properties of titanium in this application, North American worked out two machining operations and an adhesive bonding technique.

ILLING THE FACE PLATES: The titanium face plates are tapered, from .090 in. thick at one end to 0.045 n. at the other. This taper is chieved by milling the sheet, in ne pass, with HSS cutters. During the operation, the work is completely submerged in a solution of ne part denatured alcohol and ree parts water. Cutting speed 180 rpm, with feed rates from 5 20 ipm.

DHESIVE BONDING: The tapered kin is bonded to the honeycomb ore with Bloomingdale Rubber Company's HT-424 adhesive. A our-step preparation was developed for this operation: vapor degrease, acid pickle (25-35% HNO_3 lus 2-4% HF), application of fluoide phosphate coating, and hot ater rinse.

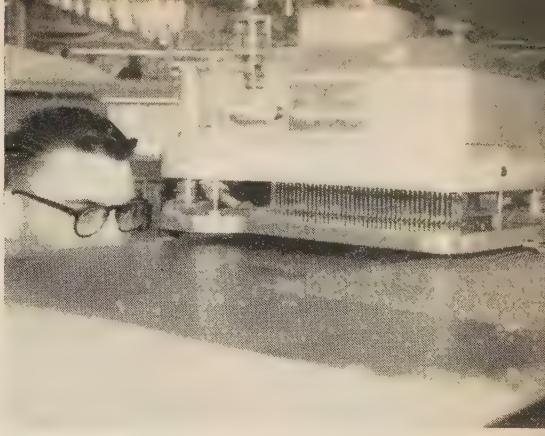
RILLING 16,000 HOLES: After the kin is bonded to the honeycomb ore, 16,000 holes 0.050 to 0.060 h. diameter are multi-spindle rilled through the skin, in a milling machine setup with a 130-pindle gearless drillhead. The ISS drills have short shanks, to inimize wear and breakage. Cutting fluid is a soluble-oil emulsion.

North American's use of titanium rimarily for corrosion resistance highlights one of the properties of titanium metal attractive in construction of:

- **ENGINES: Titanium metal eliminates the possibility of stress-corrosion or salt-water-spray pitting with its consequent fatigue damage of compressor, turbine blades and other engine parts. This is of unusual importance to commercial carriers who expect their new jets to operate 8 to 10 trouble-free hours daily. Weight advantages can provide significant economies in fuel savings alone, during seven years of operation.**
- **MISSILES: Titanium metal provides excellent resistance to the corrosive effects of rocket fuels such as liquid fluorine and ammonium perchlorate, at the same time providing minimum weight structure and outstanding cryogenic properties.**

Price reductions in titanium metal and mounting experience in working with titanium have enabled fabricators to produce assemblies with competitive advantages that more than outweigh materials cost differentials.

Titanium Metals Corporation of America has dedicated its full resources to development and production of high-strength, aircraft-quality titanium and offers the technical assistance that you may require. This effort to build a titanium industry has provided TMCA with a wealth of information that is yours when you specify Timet® titanium.



MULTI-SPINDLE DRILLHEAD mounted in milling machine makes 130 holes per pass. Surface has 16,000 holes 0.050 to 0.060 in. in diameter. Former parts were made of aluminum, which corroded and interfered with proper air flow

HONEYCOMB CORE MATERIAL is being adhesive-bonded to titanium spar (machined from Ti-6A1-4V forging), and will subsequently be bonded to tapered titanium sheet. Total weight saving of 22% is a bonus to the manufacturer. Titanium was chosen for its corrosion resistance

ULTRASONIC PROBE TESTS for completeness of bond between core and skin. Bracket at center of ramp assembly is part of a Ti-6A1-4V titanium rib, machined at North American from a Wyman-Gordon Company forging. Bracket is connected to actuator, to control pitch of inlet guide ramp

Send for: Titanium Machining Techniques, a new 32-page technical publication reviewing practical methods for turning, milling, drilling, tapping, reaming, broaching, routing, grinding and sawing of titanium.

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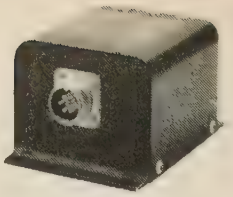
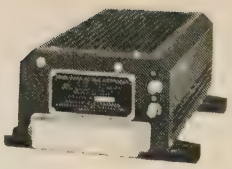
28V100MBL—Selenium TR

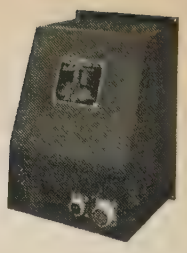
28V20—Selenium TR



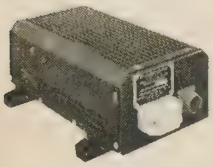
283150—Static DC-AC Inverter



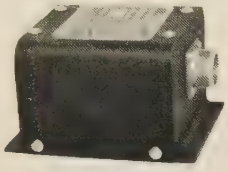
28V50C—Selenium TR



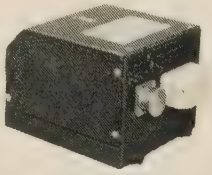
28VCP-A—Silicon TR



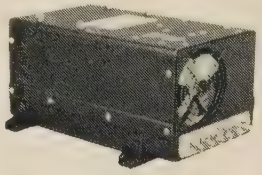
28VS100C—Silicon TR



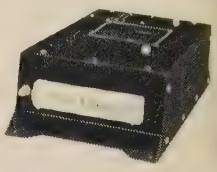
7VS20C—Silicon TR



28VS50—Silicon TR



28V-100-1—Selenium TR



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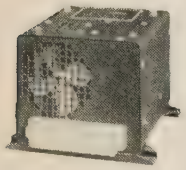

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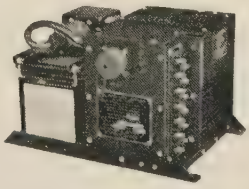
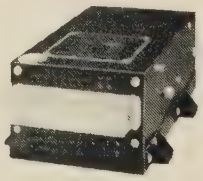
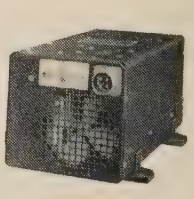


28V30BP—Selenium TR

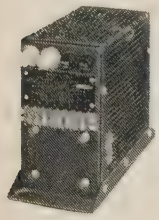


28V100BL—Selenium TR

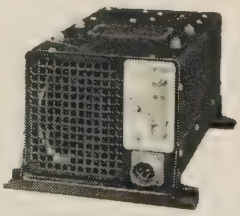
75D2D50—DC-DC Converter



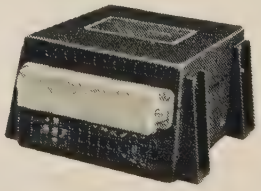
28V200—Selenium TR



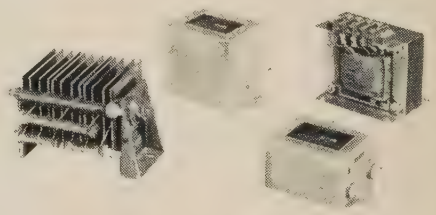
28V12—Selenium TR



28V100M—Selenium TR



28VS100 BL-1—Silicon TR



28V5—Selenium TR

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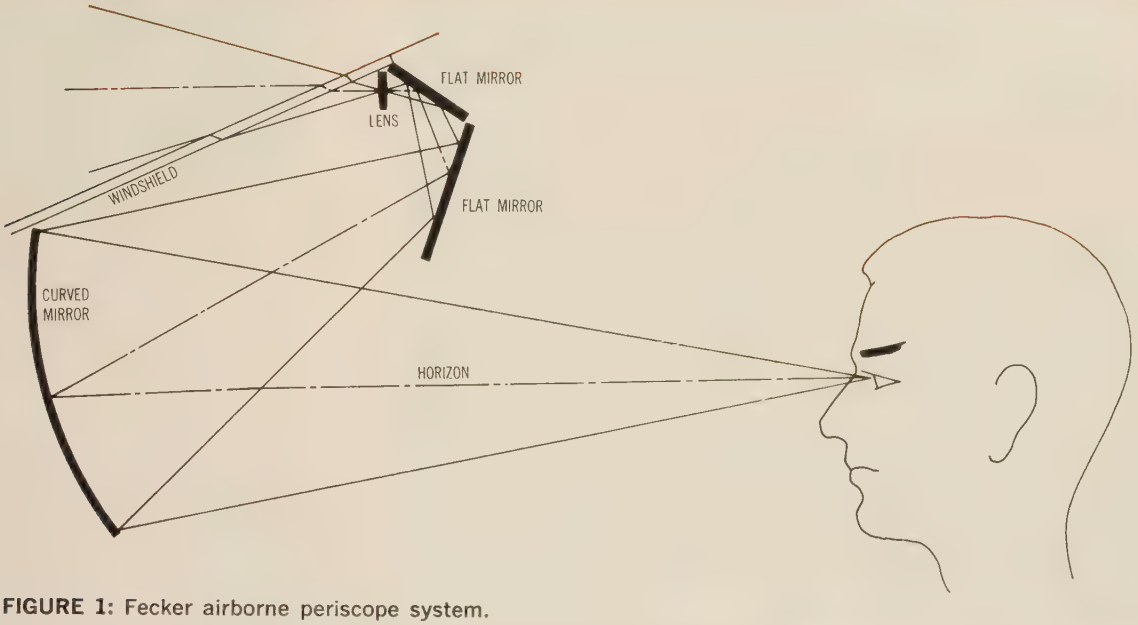


FIGURE 1: Fecker airborne periscope system.

Simple periscope

protects pilots from nuclear flashes

Protecting crews from sudden, high-intensity light flashes, such as those due to a nuclear explosion is a new consideration in aerospace vehicle design. One solution would be to use an optical viewing device that can be closed quickly.

by Ralph Wight, Chief Physicist, J. W. Fecker, Inc.*

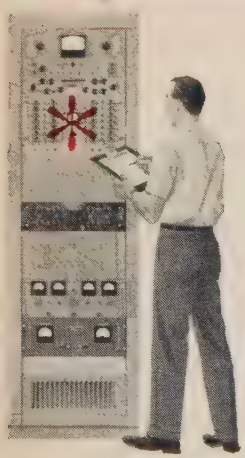
ONE of the problems of our peculiar age is the protection of crew members of aerospace vehicles from sudden exposure to high intensity light flashes, such as those from a nuclear explosion. To solve this problem, Fecker developed an optical viewing system capable of rapid closure. An operational design could have a maximum weight of 40 lb with a closure capability of 500 μsec or less. It also could be quickly removable from the pilot's forward field of view.

The system is based on a forward-vision periscope originally developed by American Optical (of which Fecker is a subsidiary) to solve the windshield problem of high speed aircraft. As *Figure 1* shows, light enters the system through an objective lens with positive refracting power in a vertical meridian only and no such power in the horizontal meridian. In other words, its a cylindrical lens whose axis is horizontal. In the model shown in *Figure 2*, this lens has refractive power of about five diopters and thus a focal length in one meridian of about eight inches.

Immediately behind the objective lens are two mirrors that reflect the entering light forward to the front of the cockpit and also invert the image. The light then falls onto a concave, cylindrical mirror with a horizontal axis, from which it passes to the eye of the pilot.

more on next page

* J. W. Fecker, Inc., 6592 Hamilton Ave., Pittsburgh 6, Pa.



Shown here:
portion of Arnoux-built
telemetry-receiving station.

No technical hold ever resulted because of an Arnoux Telemetering Decommutation System (TDS)...none has ever been returned for factory attention. Routine, minimal field-support calls have kept each unit functioning efficiently and accurately. Engineers prefer the TDS because it's actually possible to "adjust-in reliability."

* The Arnoux TDS accepts all PAM & PDM IRIG inputs...is modular, compact, small...built-in calibration...any channel easily replaced with standby plug-in units...independent linearity within ±½% of full scale...long-term level drift within ±½%...no errors due to SCO center-frequency drift or discriminator dc output-level drift or tape-playback speed variations...no heating problems...simple, novel circuitry. BULLETIN 800b.

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FIGURE 2: Full scale model of viewing system has 24-in. objective lens. The eye mirror is 12 in. wide, nine inches high, and positioned about 16 in. from the pilot.

The instrument can be compared to a simple telescope. If a distant object is examined, parallel light falls on the objective lens and is focused in the vertical meridian about eight inches from this objective. After two mirrors have erected the image, light from each point of the image diverges to the concave mirror, which lies at a distance from the image equal to its focal length. Light diverging from points on the image is collimated by the last mirror.

This mirror corresponds to the eye-piece of a telescope and may be called an "eye mirror." If you make the focal length of the objective equal the focal length of the eye mirror, you get a unit power telescope. In this case, faraway objects are seen with the same angular size through the periscope as they're seen without it.

Unlike a conventional telescope, however, the Fecker system uses cylindrical components. As a result, there's no influence in the horizontal plane on the rays entering the system. All the components act as if they were plane windows or mirrors in the horizontal meridian. Objects seen through them subtend the same angular size as when seen directly. The assembly may be said to have unit magnification.

The combination of lensless periscope and unit-power periscope gives the pilot a field of view seen at is natural size and proportions. Stereoscopic effects are undisturbed, and stereoscopic judgments can be accurately made.

All the light entering the system must pass through the objective lens. An image of this lens is formed by the eye mirror at a

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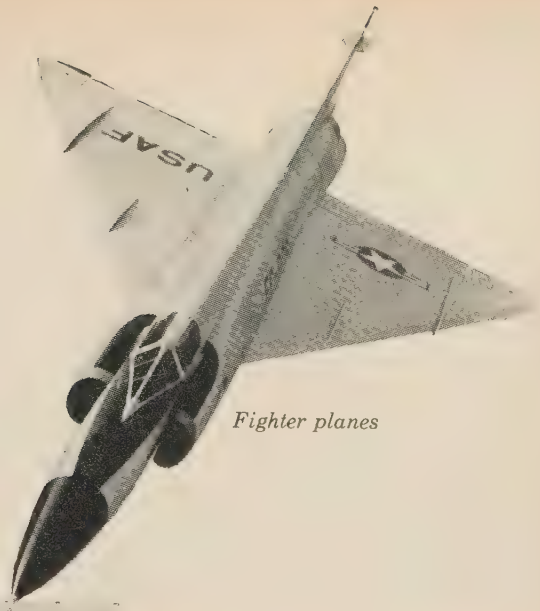
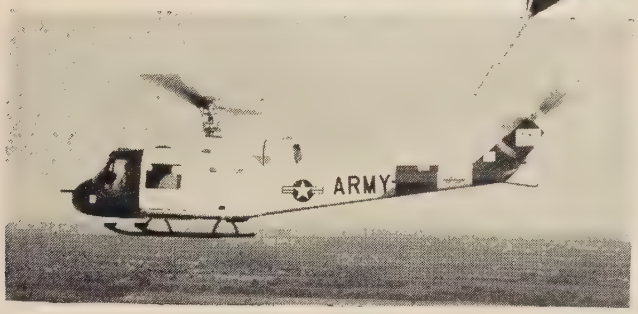
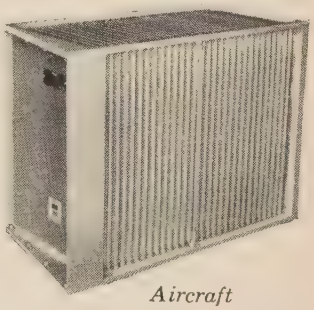


Fighter planes



Helicopters



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Our custom production policy is made possible by the flexibility designed into all Anaconda Aluminum's modern plant facilities. Your order is scheduled promptly. And, from the moment it's written until it's shipped, your order gets the personalized attention of aluminum experts at every stage—another important part of this basic policy of making sure your aluminum is exactly right.

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TYPICAL view through a system as shown in Figure 2.

distance equal to the mirror's radius of curvature. In the model, this is about 16 in. The image will have the same vertical size as the objective lens. This height is the so-called "exit pupil" of the system.

If the pilot's eye is located in the exit pupil, he will see the full field of view in substantially its original intensity, diminished only by the transmission losses of the system. If he lifts or lowers his head out of it, he will see nothing in the periscope. If he moves his head too far forward or backward, he will still see a clear picture, but the vertical field will be reduced or vignetted.

The design of the periscope must be a compromise—it must combine a large exit pupil (to give more freedom of head movement) with small components and a small windshield. The model has an objective lens that is one inch high, so in this case the pilot has a one-inch exit pupil. It has been shown that, under ordinary circumstances, this is enough for comfortable observation. However, flight tests would be needed to make sure that the same holds true for a plane in flight. It's possible, incidentally, to make the exit pupil move up and down with the movement of the pilot's head.

Although the exit pupil is limited vertically, it's very wide, so the pilot isn't constrained laterally. In fact, he can greatly increase his lateral field of view by moving his head.

In the model, the eye mirror is 12 in. wide and nine inches high. It is 16 in. from the pilot, so that he's presented with an instantaneous angular field of about 30 deg vertically and 40 deg horizontally. In addition, he can see

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New UNION readout instruments withstand shock, vibration and extreme temperature changes

Union Switch & Signal's new READALL* readout instrument replaces complicated systems of lights and relays for reading, storing or transferring all types of information for industrial and military applications. It is not to be confused with conventional indicating devices.

Designed to meet requirements of MIL-E-5422D. The new READALL readout instrument is precision-built and provides instantaneous and continuous operation under conditions of shock, vibration and extreme ranges in temperature. The digital display includes characters in numerical sequence from 0 to 9 plus two blank spaces. 7/32-inch characters can be illuminated red or white as desired; when not illuminated, they appear white against a black background.

Reliability. Performance through one million random operations is an inherent feature of the new READALL instrument. Each module is gasket-sealed in its case to exclude moisture and seal out foreign particles. An especially thin enclosed DC motor, containing ball bearings, permits more efficient operation.

Modular Construction. A unique feature of the readout instrument is its modular construction. It can be used individually or in groups to display multiple characters in a single case.

Direct Code Translation. The operation of the READALL readout instrument is based on a positioning system using a four-bit code. The visual display is the result of a direct electro-mechanical conversion of a binary signal to a decimal read-out. There is no need for additional conversion equipment. Separate code and motor circuits permit the use of the readout instrument in low-level circuitry.

Electrical and Visual Data Storage. Once positioned, the information is displayed until a new code is transmitted to the instrument. No power is consumed while the information is retained. This data may be stored or read-out electrically for further transmission or recording.

Operate Time. The operate time varies from 0.1 second to 1.0 second depending on character position.

Weight and Size. Maximum weight including case is seven ounces; without case, four and one-half ounces. Size encased is 5 13/64 inches long, 1 47/64 inches high and 39/64 inch wide. The new READALL instrument is designed for operation over a temperature range of –54°C to +71°C in humidities up to 100% and altitudes up to 70,000 feet. For more information, write for Bulletin 1019.

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"Mini-Spot" Fan

Extreme size range of Pesco Axial Flow Fans covers most space age requirements. Tiny unit shown here is 4-oz. Pesco "Mini-Spot" Fan with built-in motor which delivers 33 cfm for spot cooling. It is dwarfed by 44,000 cfm all-welded steel fan for giant vacuum cleaner which sweeps jet runways.

Other Pesco fans have been custom-designed for cooling electronic units, missile support systems, aircraft compartments and helicopter engine oil.

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Runway Sweeper Fan

Your project can receive a major assist from Pesco capabilities in the development of axial flow fans for diversified applications.

Pesco creative engineering produces optimum designs based on the most advanced aerodynamic principles. Close internal design-production coordination means maximum performance and reliability. Integrated facilities permit delivery of prototype and production units to meet tight deadlines.

For ingenious, economical solutions to fan problems, utilize the creative engineering available at Pesco.

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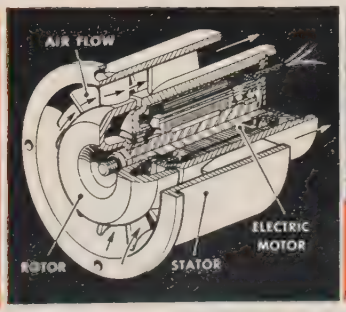
Miniaturized "package" design utilizes integral Pesco motor for minimum weight and size. Axial flow principle assures maximum air flow and pressure.



Highly skilled fan engineers are backed up by extensive Pesco research, testing and production facilities *plus* Borg-Warner Central Research.

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another 15-20 deg right and left by moving his head. Preliminary calculations show that in operational systems a vertical field of at least 37 and possibly 40 deg and a horizontal field of 60 deg can be provided.

Because there's no refractive power in the horizontal meridian, the objective lens must be on an order of magnitude of twice the width of the eye mirror. In the model, the lens measures 24 in.

It should be emphasized that there's no inherent relationship between the lateral and vertical dimensions of the components in this system. Therefore, the field of view can be made tall and narrow, wide and shallow, or tall and wide.

If the telescope is in excellent adjustment, the forward-looking field of view will be essentially identical with that seen through a conventional windshield in the same direction. In this case, it's an advantage to arrange the periscope so that the lower edge of the view seen directly through the windshield precisely coincides with the upper edge of that seen in the periscope (*Fig. 3*).

FIGURE 3: Useful vertical field can be expanded by having the lower edge of the view seen through the windshield (light strip at top) coincide with the upper edge of the periscope view. In the periscope view here, the woman's figure is 20 per cent elongated because of slight distortion effect of the system at short distances. At longer distances, this effect is negligible.

Figure 3 also shows another curious property of the periscope: In the vertical meridian, the eyes have been moved about 32 in. closer to the object, while in the horizontal meridian they haven't been moved at all. Because of this effect, an object 32 in. from the objective lens seems double in vertical height compared with its horizontal dimensions. At a distance of 27 ft, the effect will amount to only about 10 per cent and should be just barely noticeable; at greater distances, it's negligible. If necessary, however, the magnification of the telescope can be changed in the vertical meridian to eliminate this effect.

Rapid closure can be achieved by either explosive actuation or mechanically stored energy. The latter method has recently been used by Fecker to control a very large "venetian-blind" light attenuator for a solar furnace. This shutter measures 108x108 ft and operates in 1/10 sec. On a greatly reduced scale, much higher speeds are possible. Current work also indicates that explosively actuated shutters with the speed required for the Fecker system can be designed. Write in No. 70 on Reader Service Card for more information.—End

Hydraulic and pneumatic lines are quickly and easily connected with Hansen Two-Way Shut-Off Couplings. No tools required.

When Coupling is disconnected, valves contact valve seats in both Socket and Plug to provide instant and positive seal of fluid in both ends of line. Coupling does not depend upon line pressure to seal either end of line.

Six sizes are available, with female pipe thread connections from 1/8" to 1" respectively. Furnished either in steel or brass.

Representatives in Principal Cities . . . See Yellow Pages

Instantly shuts off both sides of line . . . prevents loss of liquid, gas or pressure.

Quick-Connective Fluid Line Couplings for

COMPRESSED AIR • OIL
GREASE • HYDRAULIC FLUIDS
WATER • VACUUM • STEAM
OXYGEN • ACETYLENE
REFRIGERANTS • GASOLINE
COOLANTS • LP-GAS

Write for the Hansen Catalog

Here is an always ready reference when you want information on couplings in a hurry. Lists complete range of sizes and types of Hansen One-Way Shut-Off, Two-Way Shut-Off, and Straight-Through Couplings.

SINCE 1915 QUICK-CONNECTIVE FLUID LINE COUPLINGS

THE HANSEN MANUFACTURING COMPANY

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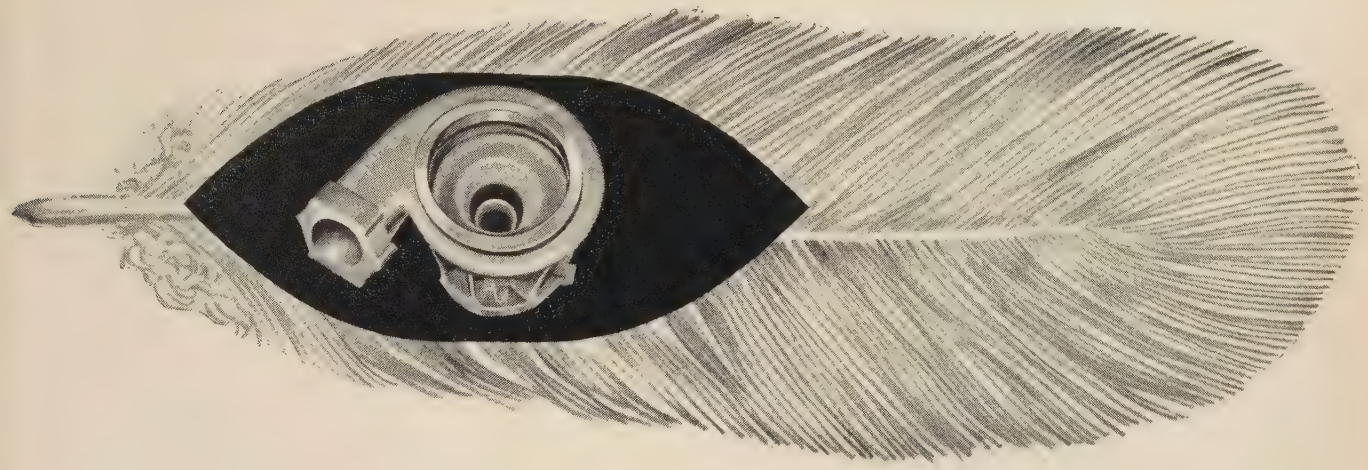
new weight saving material for missiles and high performance jet aircraft



NEW HIGH-STRENGTH . . .
HIGH-PURITY ALUMINUM CASTING ALLOY

If you've been pushing A-356 to the limit of its physicals to scrape off every possible ounce of excess weight . . . then new alloy MA-356 was made to order for you. With a few minor changes in chemical composition, Rolle has produced what is essentially a new casting material. Highly responsive to heat treatment, it permits higher tensile strength, higher yield strength, and greater elongation. Rolle is pouring MA-356 now . . . in castings that consistently exceed the physical requirements of MIL-C-21180A. Check, for example, the typical sand cast range of properties MA-356 permits in the T-6 condition against what you can expect from conventional A-356 at left:

ALLOY (T-6)	U.T.S. (psi)	Y.S. (psi)	E (%)
A-356	40,000	30,000	3
MA-356			
minimum	40,000	30,000	5
maximum	50,000	40,000	2

One of the advantages of MA-356 is that any desired physical within the typical range can be emphasized through careful control of heat treatment of the casting. Even more exciting are the extremely high physicals that have been achieved with MA-356 in favorable casting configurations. Test castings have actually exceeded a tensile strength of 54,000 psi and yield strength of 44,000 psi with 2% elongation.

But no two castings are alike. It's impossible to predict the benefits MA-356 will confer on your sand and permanent mold castings without prints and specs. If you'd like more information on this new alloy, write for Technical Data Bulletin 1001. And when you do, why not ask for your copy of our 58-page light metals casting handbook . . . an engineering guide to aluminum and magnesium sand and permanent mold castings. Rolle Manufacturing Company, 301 Cannon Avenue, Lansdale, Pennsylvania, or call ULysses 5-1174.

ROLLE

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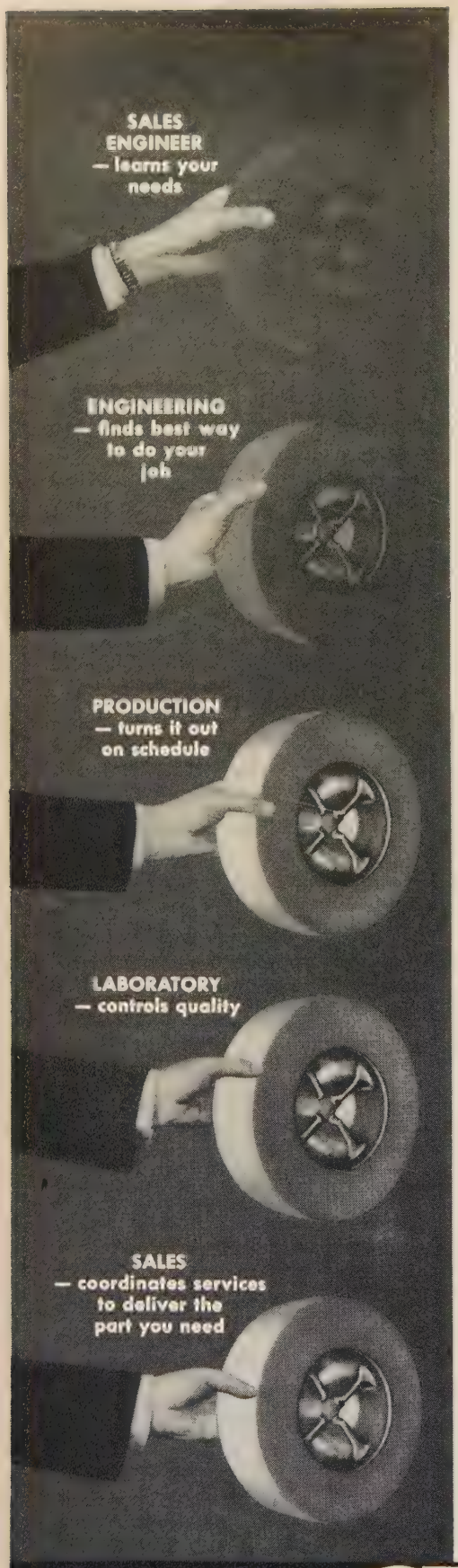
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ENGINEERING — finds best way to do your job
PRODUCTION — turns it out on schedule
LABORATORY — controls quality
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that helps you DEVELOP and GET the part you need

When you go to T & W for forgings or stampings, an entire team swings into action. Experts working together solve problems and get results — perform at a level far above that which "routine" handling provides. *T & W Technique* develops for you forgings and stampings meeting your most exacting needs.

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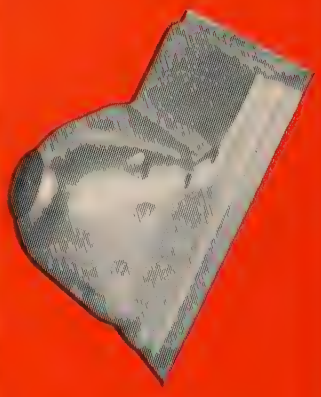
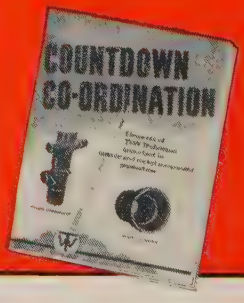
The forging in the illustration at left is a missile part, meeting requirements of the exacting kind encountered for rocket, missile, and aircraft production.



T & W Technique makes possible production of many parts unusual in contour or tolerance, from various alloys. Above is a stainless steel stamping a tank 25" x 18½" x 12½".

Write for COUNTDOWN COORDINATION, showing how T & W facilities can help you.



FORGINGS & DEEP DRAWN STAMPINGS

TRANSUE & WILLIAMS
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Company _____
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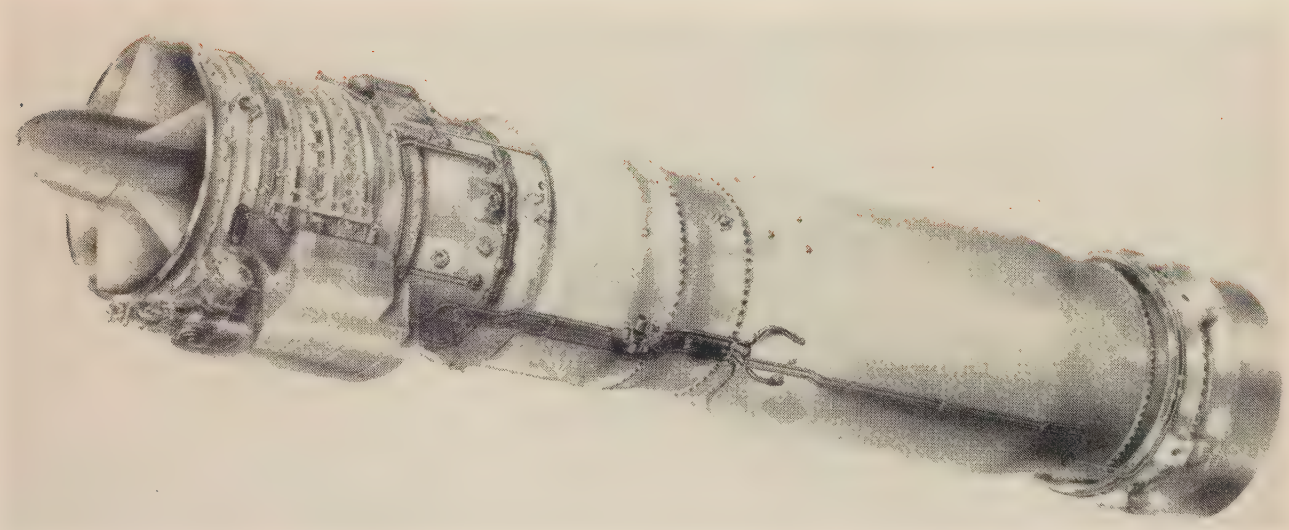

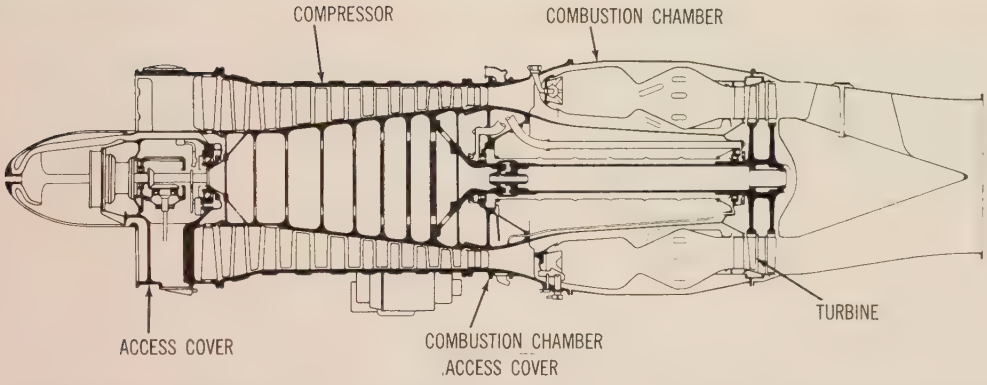

AMONG SNECMA's latest jet designs are the developmental Mach 3 Super Atar (top) and the Mach 2 Atar 8 (bottom), which is already in production.

French push Atar jets up to Mach 3

Few if any series of jet engines has racked up as impressive a record as Snecma's Atars, for which the first prototype was tested way back in 1948. Today this highly adaptable engine is being groomed for flight at Mach 3.

by Robert Roux, French Corresponding Editor

TWO Mach 2 jet engines are now in production at S.N. d'Etude & de Construction de Moteurs d'Aviation (Snecma), 150 Blvd. Haussmann, Paris 8, France—the Atar 8, with 9700 lb maximum thrust, and its afterburner-equipped counterpart, the Atar 9, with 13,230 lb maxmium thrust. A successor to these engines that will be suitable for Mach 3, the all-steel Super Atar, is in development.

The Atar 8 reflects many of the lessons learned in the design of previous models in the Snecma series.

more on next page

Now! Special, Timesaving Snap-on Tool Kit for Electronic Assembly and Maintenance

5343-ET-B ELECTRONIC ASSEMBLY TOOL SET

43 tools including ¼-in. sq. drive ratchet, extensions, Flextension, universal joint and 2 plastic-handle drivers; 9 sockets, 3/16" to ½"; 4 open-end wrenches, 3/16" to 7/16"; 4 Boxocket® wrenches, 3/16" to 11/32"; 10 screwdrivers, Phillips and standard bits; screw starter; 6 pliers and cutters; soldering iron.

This new SNAP-ON kit of specially selected tools is made up to reduce costly labor time on electronic assembly and maintenance work.

Tiny wrenches slip between closely fitted assemblies on nut-turning jobs. Smooth, well-shaped handles aid efficiency of both men and women assemblers.

Thin blade tips on screwdrivers, with tips the same width as shank diameter, follow screws below surfaces, can reach in among intricate assemblies.

Pliers include needle nose, duck bill and diagonal cutter with plastic-covered handles — also midget tapered nose cutter, midget gripping pliers and special needle nose gripper-cutter. Both diagonal cutters have plastic jaw inserts which hold wire cutoffs.

Eighteen-watt, pencil-type soldering iron maintains constant 850° F. tip temperature for work on printed circuits or tiny assemblies. Entire set fits neatly in strong metal box for convenient carrying or storage.

These tools are top quality throughout — cost less because they outlast cheaper tools over and over. Use of fine steels permits light weight, slim, yet strong, tools that fit properly.

Put new speed on your assembly line with this SNAP-ON electronic tool set or one especially selected for your specific jobs. Write us or call your nearest SNAP-ON branch.

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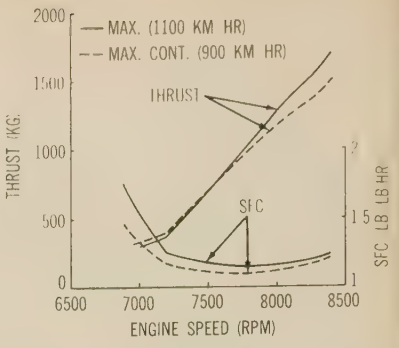


THRUST AND SFC of Atar 8 at 36,100 ft (11 km) and various power ratings.

It has a nine-stage axial-flow compressor, an annular combustion chamber, a two-stage turbine, and a variable-area nozzle, The accessories are all combined in a new location at the lower part of the compressor housing.

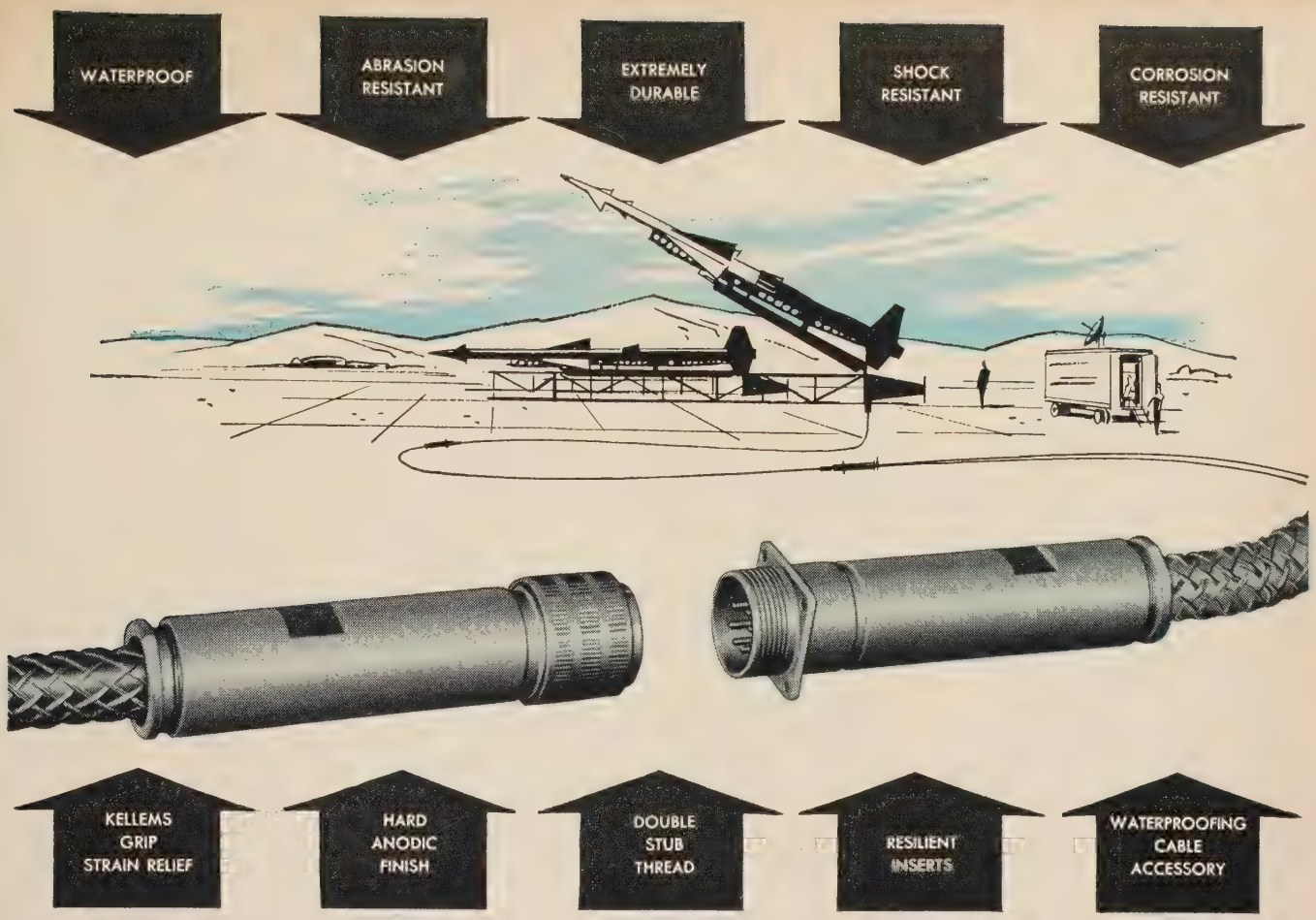
With its six struts, the Atar 8 intake housing departs from previous Atar designs. It houses the stainless steel intake guide vanes and hollow stator blades through which hot de-icing air flows; the front main bearing, a deep-grooved ball thrust type; and the wheel case, from which both engine and aircraft accessories are driven.

Turbine air starter in intake bullet

A turbine air starter is housed in the intake bullet inside a cowling in which hot air is circulated. It is connected to the main shaft through a dog coupling. Through the inside of the hollow intake struts run drive shafts to an external bevel box driving the aircraft accessories and to another, angled drive-shaft driving the engine accessories; the starter air duct; and an oil drain pipe from the wheel case.

The compressor's nine stages of blading originally were to be made of a light alloy, but a high temperature alloy is now being substituted. At the front end of the rotor, an extension shaft takes the front ball bearing; it is coupled through an intermediate shaft to the starter dog coupling. At the rotor's rear end, another extension shaft takes the center roller bearing and, through a splined sleeve, is connected to the turbine shaft.

more on page 100



Why it pays you to specify

BENDIX QWL ELECTRICAL CONNECTORS FOR USE WITH MULTI-CONDUCTOR CABLE

Used extensively on ground launching equipment for missiles and on ground radar, and other equipment, the Bendix* QWL Electrical Connector meets the highest standards of design and performance.

A heavy-duty waterproof power and control connector, the QWL Series provides outstanding features:

- The strength of machined bar stock aluminum with shock resistance and pressurization of resilient inserts.
- The fast mating and disconnecting of a modified double stub thread.
- The resistance to loosening under vibration provided by special tapered cross-section thread design. (Easily hand cleaned when contaminated with mud or sand.)
- The outstanding resistance to corrosion and abrasion of an aluminum surface with the case hardening effect of Alumilite 225 anodic finish.
- The firm anchoring of cable and effective waterproofing provided by the cable-compressing gland used within the cable accessory.
- The watertight connector assembly assured by neoprene sealing gaskets.
- The additional cable locking produced by a cable accessory designed to accommodate a Kellems stainless steel wire strain relief grip.
- Prevention of inadvertent loosening insured by a left-hand accessory thread.
- The high current capacity and low voltage drop of high-grade copper alloy contacts. Contact sizes 16 and 12 are closed entry design.

These are a few of the reasons it will pay you to specify the Bendix QWL electrical connector for the job that requires exceptional performance over long periods of time.

*TRADEMARK

Export Sales and Service: Bendix International Division, 205 E. 42nd St., New York 17, N.Y. Canadian Affiliate: Aviation Electric Ltd., 200 Laurentien Blvd., Montreal 9, Quebec. Factory Branch Offices: Burbank, Calif.; Orlando, Florida; Chicago, Ill.; Teaneck, New Jersey; Dallas, Texas; Seattle, Washington; Washington, D. C.

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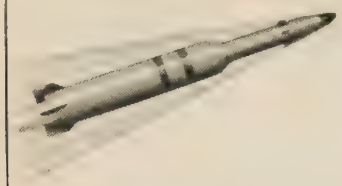
ELECTRONICS: Over, on and under...



INTERESTED IN TRANSISTOR CIRCUITRY?

Here's the challenge at Autonetics—can you develop *original techniques* in transistor circuitry, from either a component or systems level, for any or all of the following systems:

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If you have a BSEE and several years of design, research, development or test experience in transistor circuitry, you can pick your field and share in the many "first" achievements of Autonetics young engineers.

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Autonetics
A Division of North American Aviation, Inc.

Check Employment Inquiry Form on Page 183

Atar 8 & 9: Static Performance

Rating	Thrust		RPM	SFC
	Pounds	Kilograms		(lb/lb-hr)
	Atar 8			
Maximum	9700	4400	8400	0.98
Intermediate	8800	4000	8300	0.95
Maximum continuous	7740	3550	8150	0.935
Cruise	6835	3100	8000	0.925
	Atar 9			
With afterburning				
Full	13,230	6000	8400	2.07
Partial	11,900	5400	8400	1.69
Without afterburning				
Maximum	9370	4250	8400	1.01
Intermediate	8490	3850	8300	0.99
Maximum continuous	7495	3400	8150	0.97
Cruise	6500	2950	8000	0.97

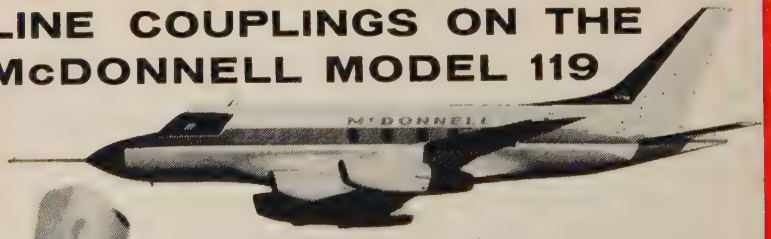
The compressor housing is produced in two halves, to which the nine rows of stator blades are attached. It is made of a light alloy, but it seems certain that Snecma eventually will switch to high temperature alloys in this case, too.

The combustion chamber consists of an inner, light-alloy ring, the so-called "center casing", and an outer shell of heat-resistant steel. To the center casing, 20 burners are attached. Two of these

more on page 103

ON MARK COUPLINGS

NEW ON MARK FLEXIBLE LINE COUPLINGS ON THE McDONNELL MODEL 119



Standard equipment on the McDonnell Model 119 fuel lines is ON MARK's new Flexible Fluid Line Couplings. Vastly superior to old style "AN" tube unions, this new coupling has been tested far beyond the requirements of specification MIL-C-25014 with simultaneous flexure, axial motion and pressure cycling at −65°F WITH NO DEVIATION. Simpler in design, easy to assemble (NO SPECIAL TOOLS NEEDED), and lighter, the ON MARK coupling seals on deformed, marred and scratched tubing at all temperatures. Tests prove these couplings to be equally effective for special requirements such as hot air, gases, exotic fuels, and vacuum. *In production* in standard tubing sizes.

For full information please contact

ON MARK COUPLINGS, INC.
4440 York Boulevard, Los Angeles 41, California
Telephone CLinton 4-2278

Representatives: Airsupply Company, Beverly Hills, Calif.; Aero Engineering Company, Mineola, Long Island, N.Y.—Divisions of The Garrett Corporation;

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Write in No. 47 on Reader Service Card

FLAME-PLATED WITH TUNGSTEN CARBIDE...

PIONEER'S THRUST CHAMBER TAKES BLASTING HEAT—LASTS 50% LONGER!

Aerojet General Corporation added 50% more operating life to Pioneer's second-stage thrust chamber with Linde's Flame-Plating process. Now, the lightweight aluminum tube, Flame-Plated with a thin (.003 in.) coat of tungsten carbide, has thermal and erosion resistance that stands up to the metal-killing temperatures of the combustion flame.

With this special Linde process, you can have metals coated with tungsten carbide, aluminum oxide, and other materials to provide outstanding resistance to wear, abrasion, and fretting corrosion, even at extreme temperatures. If necessary, these coatings can be ground and lapped to one micro-inch rms or better. They consistently outlast hard chrome plating, tool steels, and in some cases, solid tungsten carbide.

When coatings of refractory metals such as pure tungsten, tantalum, molybdenum, and other ultra-high-melting-point metals are desired, Linde Company offers its new "Plasmarc" Torch service. To find out how Flame-Plating or the "Plasmarc" Torch service can solve your critical temperature and wear problems, write Dept. SN-09, Linde Company, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N.Y.

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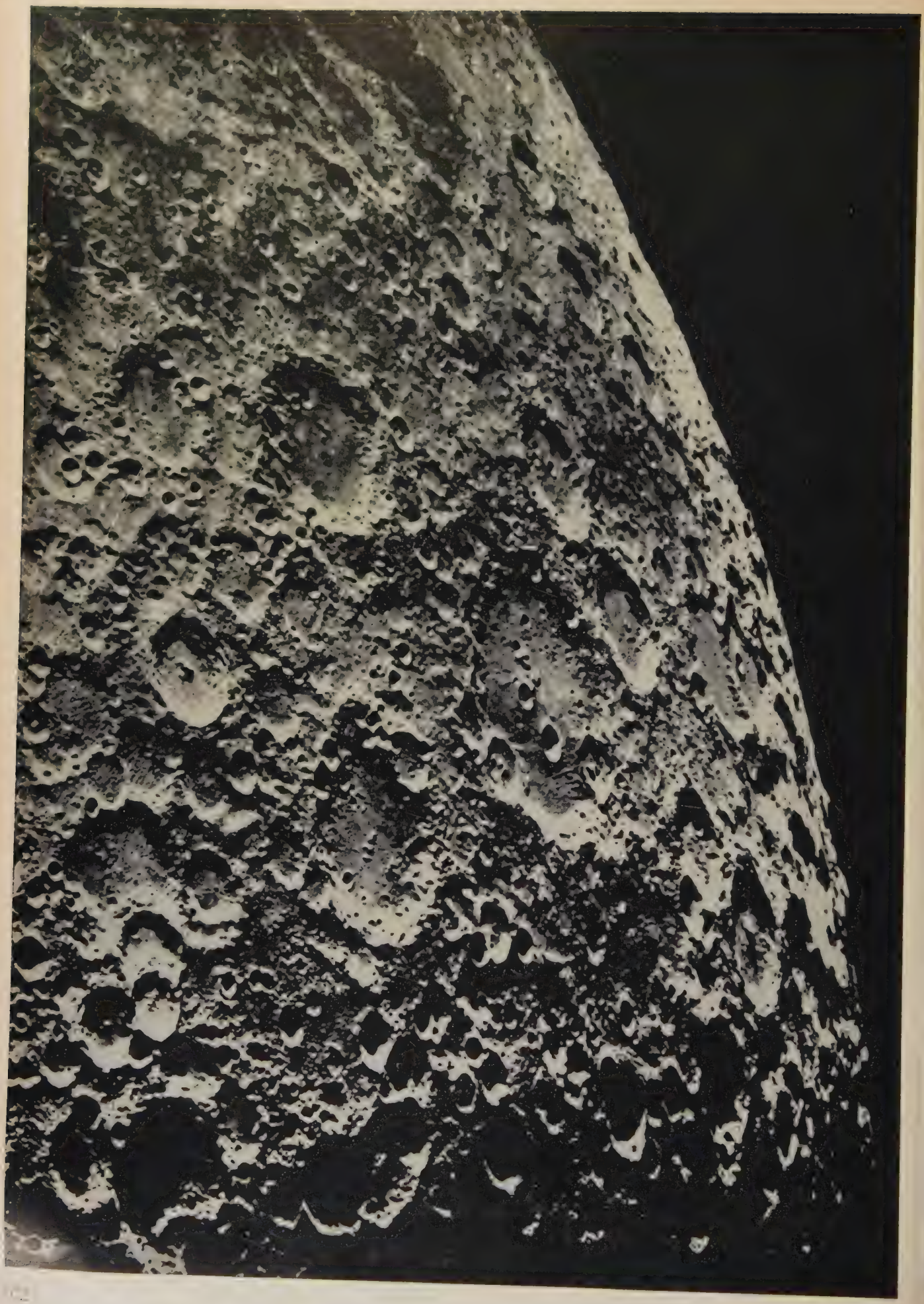
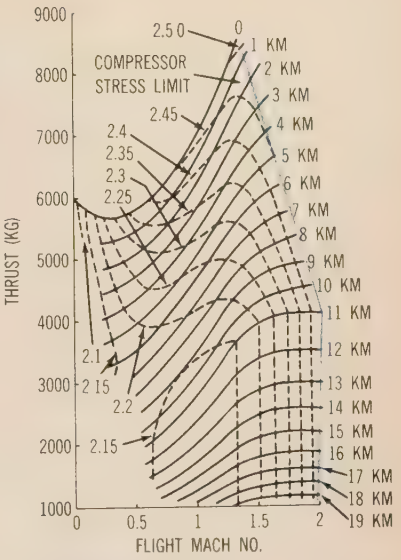


SPACE/AERONAUTICS



THRUST of the Atar 9 at maximum afterburning under ISA conditions for various altitudes and SFCs.

carry igniter plugs to insure instant firing and re-firing. Inside the center casing are the center bearing and the coupling sleeve connecting the compressor rotor and the turbine shaft. The center casing also carries the three main suspension trunnions of the engine.

The outer shell is bolted to the center casing. It surrounds two concentric, cylindrical, perforated flame tubes provided for diluting secondary air flow as well as a shell arrangement acting as the turbine bearing assembly.

Two-stage turbine is new on Atar 8

As a two-stage design, the Atar 8's turbine breaks with tradition—all earlier Atar turbines have only one stage. Each of the Atar 8 turbine's stages is a steel disk. The first disk is integral with the turbine shaft, and the second is coupled to the first turbine wheel by axial teeth and to a sleeve threaded into the turbine shaft with radial splines.

The first disk is cooled by compressor bleed air flowing within an outer shell that concentrically surrounds the turbine shaft. The second is cooled by air from a duct inside the turbine shaft. The turbine bearing assembly houses the rear roller bearing and carries the

more on page 105

THE
MILITARY
REQUIREMENTS
FOR
MOON BASE

This is the title of one of four major space proposals developed by Martin for the military and astroscientific branches of our Government. The importance of this proposal is two-fold: the inevitability of an actual moon base program by this country within the next 5 years, and; the fact that we could and can undertake such a project now—not in theory but in "hard" engineering design. For Martin's eight divisions add up to one of the top capabilities in the free world for man's first ventures in space-planetary exploration.

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NEW DEVELOPMENTS IN AIR NAVIGATION AND COMMUNICATIONS:

1. For tracking missiles and drones: the AN/DPN-50, a rugged, powerful, airborne C-band chain radar beacon. Range up to 1,000 miles with exceptional reliability, low weight, small volume.

2. The AN/ARN-52 (XN-1): high-performance TACAN transceiver for any aircraft, from helicopter to supersonic jets. The only TACAN transceiver with the reliability and flexibility of solid state design. 50% less power required and 50% lighter than existing equipment.

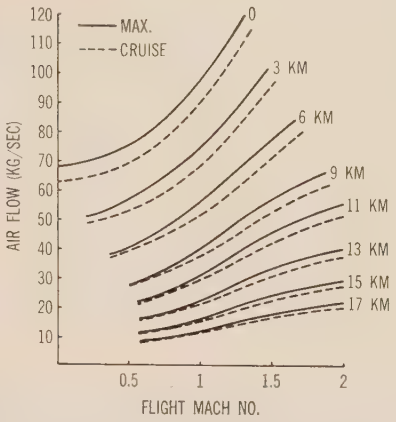
3. An air-to-ground Automatic Binary Data Link...

Economical: requires no special radio set, no high-speed printer.

Compatible: Simultaneous voice and data transmission by multiplexing on any voice channel. Data output feeds any standard teletypewriter.

Brochures on request.

S-C STROMBERG-CARLSON



AIR FLOW vs flight Mach number for the Atar 8 at maximum power (solid curves) and cruise power under ISA conditions.

turbine nozzle box. This unit consists of two stages of concentric rings carrying the nozzle vanes.

The exhaust assembly consists of the so-called "exhaust cone", the tailpipe, and the nozzle. The exhaust cone is a duct that channels the gas flow downstream of the turbine. Made of steel, it has the shape of a truncated cone. Centrally within it, there is another cone, supported by streamlined struts and forming the inner wall of the exhaust duct. The exhaust cone is insulated and fitted with a heating muff that provides hot air (used, for instance, to de-ice the intake lips).

The cylindrical tailpipe may vary in length according to the aircraft installation. (However, it cannot be shorter than 7⅞ in. [20 cm].) A heat-resistant steel shell, the tailpipe has flanges at its ends —the front flange is bolted to the rear flange of the exhaust cone and the rear flange to the nozzle flange. The tailpipe also is insulated. Depending on the aircraft installation, it may carry a secondary mounting attachment.

The nozzle is a variable-area clamshell type made of heat-resistant steel. The two clamshell shutters are operated by servo-hydraulic jacks actuated by the servo control system.

The lubricating system uses oil and is contained entirely within the engine. It consists of a tank, pump units, and ducting. Its design was determined largely by the requirements of engine operation in a vertical position. Oil consumption at maximum continuous thrust is 0.2 gph (0.75 l/hr).

Fuel is fed to the inlet duct by a transfer pump immersed in the fuel tank. At least 2100-2400 gph (8000-9000 l/hr) of fuel will be delivered at a minimum pressure of eight psi (0.55 kg/cm²) above ambient at any operating altitude.

Within the engine, the fuel passes through a heat exchanger to a high pressure pump. From there it is fed to the burners via a governor and a pressure-regulating relief valve. The governor is controlled by a single actuating lever. It keeps engine rpm and exhaust gas temperature at their proper values regardless of changes in forward speed, altitude, or air intake temperature.

The Atar 9 is identical with the Atar 8 except for its afterburner. Its maximum thrust is 13,230 lb (6000 kg), roughly 40 per cent more than the top thrust without afterburning (see *Table*). It is expected that this value will be bettered, until a thrust increase of as much as 80 per cent is provided by afterburning.

By simply moving his throttle lever, the pilot can continuously vary the thrust of the Atar 9 down to 1990 lb (900 kg) at Mach 0.7-1 and 52,500-55,800 ft (16-17 km). The Atar 8 is 21.89 ft (6.673 m) long, has a maximum diameter of 3.35 ft (1.020 m), and weighs 2750-2832.5 lb (1250-1287.5 kg).

Super Atar to resemble the Atar 9

Little has been revealed about the Mach 3 Super Atar. Snecma lists the main design requirements as:

- few compressor stages,
- wide use of steel,
- low specific weight,
- wide use of standardized parts.

Basically, the Super Atar will resemble the Atar 9, Snecma says. The rotor and stator will be entirely of steel, though, and some compressor stages will have variable stator blades. The nozzle will be a variable-geometry, convergent-divergent type. The 22,000-lb thrust class engine will have an operational ceiling beyond 82,000 ft, Snecma expects, and a specific weight of about 0.17. Write in No. 65 on Reader Service Card for more information.—End

New Fafnir AW-AK Bearings
These new airframe control bearings are designed for low torque operation at temperatures in the 500° F range. The bearings are made of heat-stabilized 440 C stainless steel, and equipped with Teflon fabric seals.

New Fafnir M-Series Bearings
Bearings in Fafnir's new M-Series—the first special precision series made for aircraft control systems—are held to closer tolerances to reduce play and backlash and increase sensitivity in power control systems.

New Fafnir GDSRP Bearings
This new series offers most capacity for weight and size. Dimensionally interchangeable with the DSRP series, GDSRP bearings are relubricatable, feature weight-saving balanced design, removable Plya-Seals, and self-alignment.

First at the turning points in jet-age design

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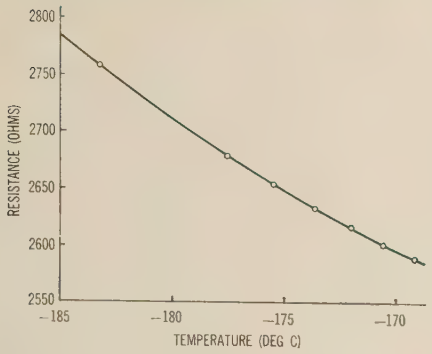


FIGURE 1: Calibration curve for an Aero-Research Instrument resistor at LOX temperatures.

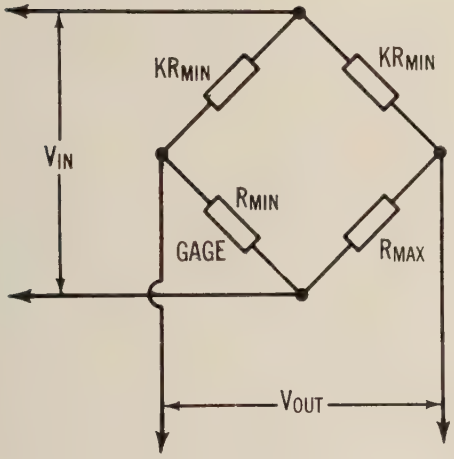


FIGURE 2: One-sensitive-arm bridge used to get 0.5 V dc from an unamplified platinum resistance thermometer.

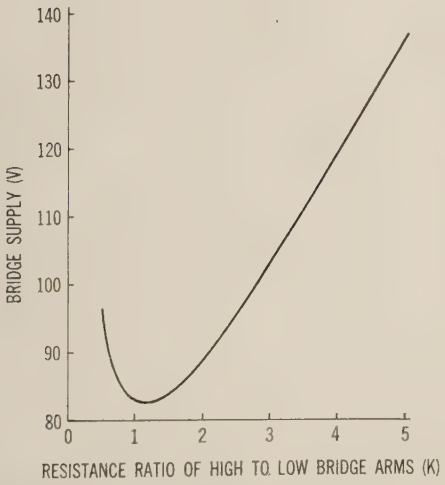


FIGURE 3: Voltage requirements of a one-sensitive-arm bridge over —185 to —170 deg C for outputs from zero to five volts.

Amplified probes measure Jupiter's LOX temperature

In-flight monitoring of LOX temperatures missile is important because boiling LOX can cause pump cavitation and so abort a whole mission. Here is a survey of LOX temperature probes and a report on the choice made by ABMA in the case of the Redstone and Jupiter.

by C. T. N. Paludan, Deputy Chief, Measuring System Section, Army Ballistic Missile Agency[1]

LIQUID oxygen (LOX) temperature must be measured during ballistic missile flights for two major reasons. One is that cavitation in the turbopump, caused by boiling of the LOX, can make the missile fall short of its target. The temperature of the LOX is raised by areodynamic heating of the missile skin, which adds energy to the LOX.

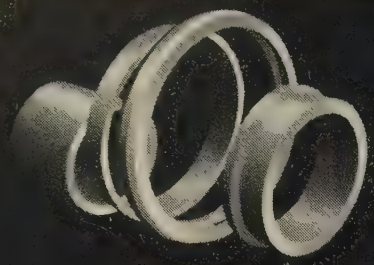
The LOX tank is normally pressurized before launching to raise the LOX boiling point. This pressurization is limited, however, by the strength of the tank. In studies of the LOX temperature at the pump inlet, cavitation can be detected.

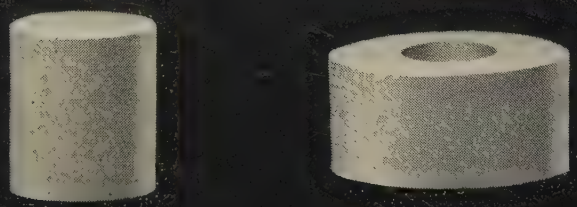
The second reason for LOX temperature measurements is that it's convenient to measure the propellant flow rate with a meter calibrated volumetrically rather than according to mass flow. To get the mass flow rate, the propellant's density therefore must be known. Since LOX's density varies with temperature, an indication of temperature is needed.

more on next page

(1) Missile Instrumentation Development Branch, Guidance & Control Laboratory, Army Ballistic Missile Agency, Huntsville, Ala. The author wishes to acknowledge the contributions of Helmut Zoike, of Servomechanisms; D. C. Ganschow, of Chrysler Missile Div.; Marvin Scadron, of Areo-Research Instrument; Vernon Westcott, of Trans-Sonics; F. A. Brennan and Dr. Herbert Sasche, of Keystone Carbon; L. B. Brooks and others, of Bendix-Friez; Messrs. Youngquist and Munnell, of Martin-Baltimore; and Dr. Hugo Woerdeman, of Magnetic Research.

why
Edgewater rolled steel rings
are best . . .



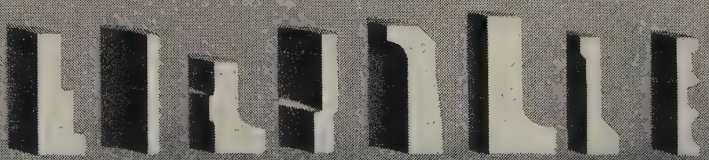


A solid steel block is heated to forging temperature, and thoroughly soaked.

The block is upset on a forging press, and the center is punched out.

On the rolling mill, the heated punched block revolves between main and pressure rolls, where its diameter grows and section shape is formed. Edging rolls control width.

Below—representative sections of rings rolled by Edgewater.



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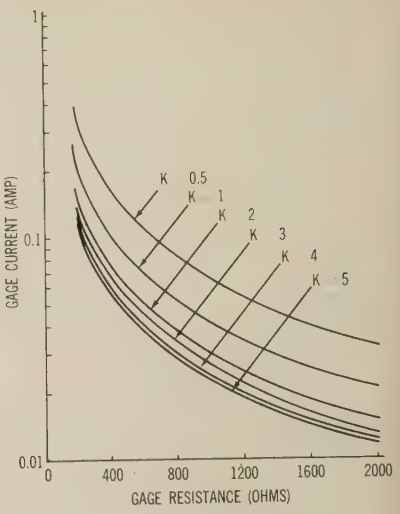

FIGURE 4: Gage current in a one-sensitive-arm bridge for various resistance ratios.

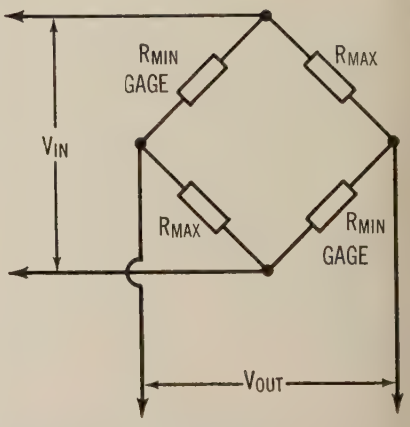

FIGURE 5: Two-sensitive-arm bridge.

This problem was studied for the Redstone missile in 1952. A literature survey showed Martin had used Friez Instrument thermistors in the Viking program.[2] Several thermistors of the same type were used successfully in Redstone flights. A number of other methods were looked into at the time and are still being studied. A. D. Little, Inc., in 1952 suggested a vapor pressure thermometer with LOX as the working fluid or a gas thermometer charged with helium.

In 1952, no suitable amplifiers were available. This ruled out resistance thermometers—it was too difficult to make any that had enough resistance. With the advent of stable amplifiers, however, re-

(2) "The Measurement of Liquid Oxygen Temperature;" Martin report, '53. W. G. Cass, "In-Flight Measurement of Liquid Oxygen Temperature;" *Aero Digest*, May '54.

more on page 111

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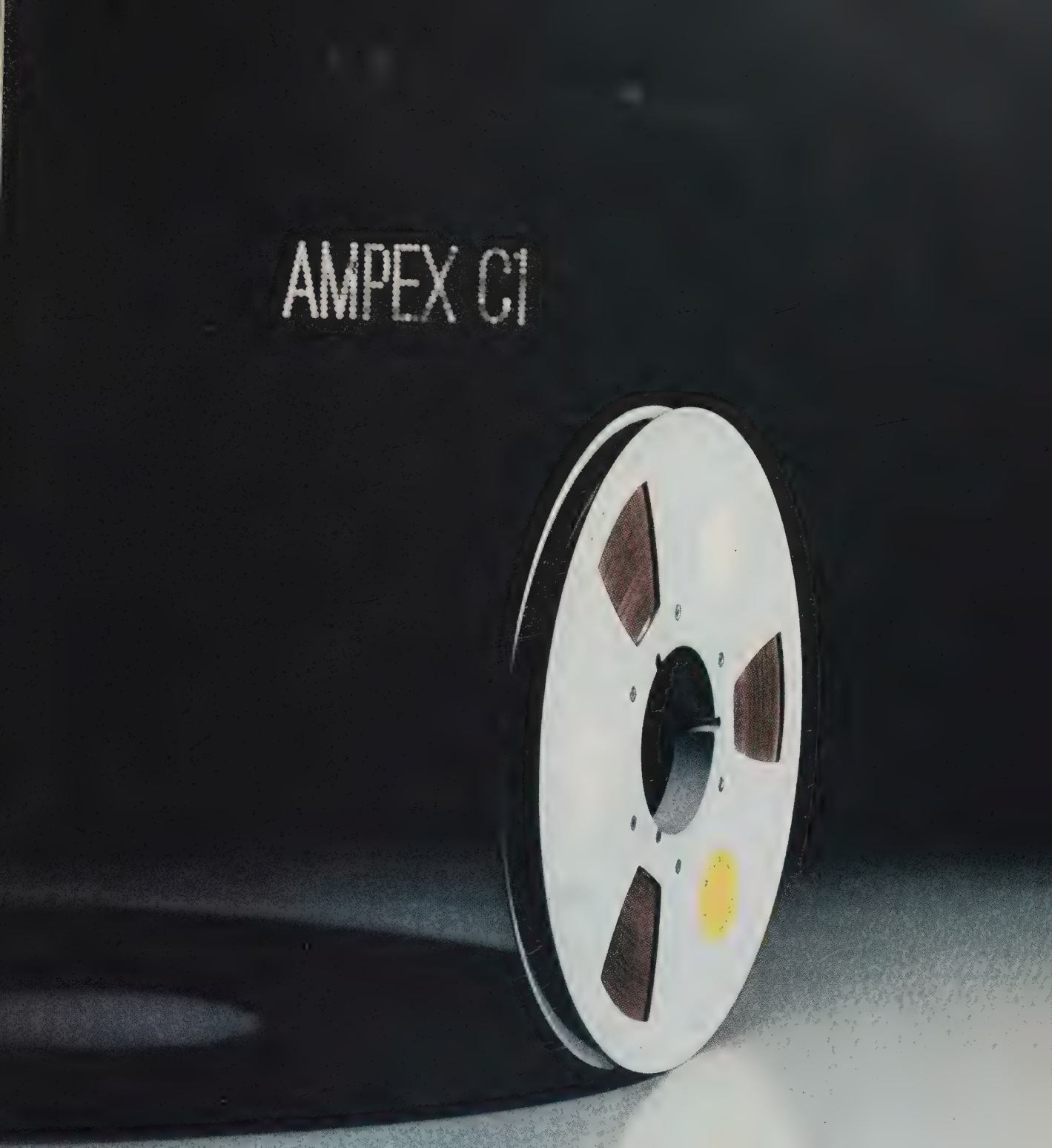

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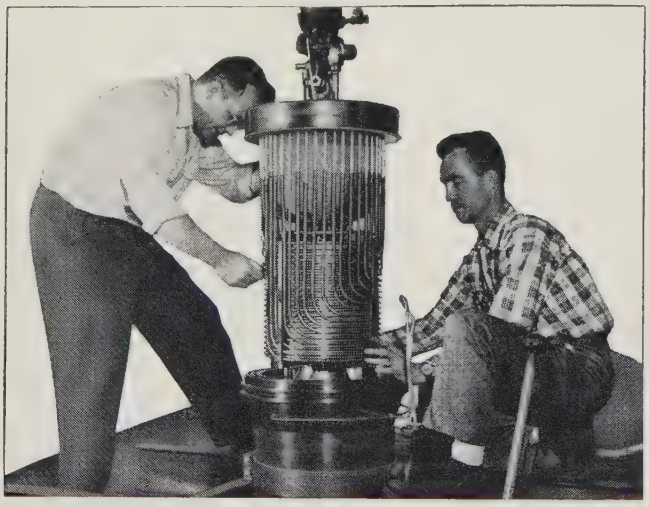

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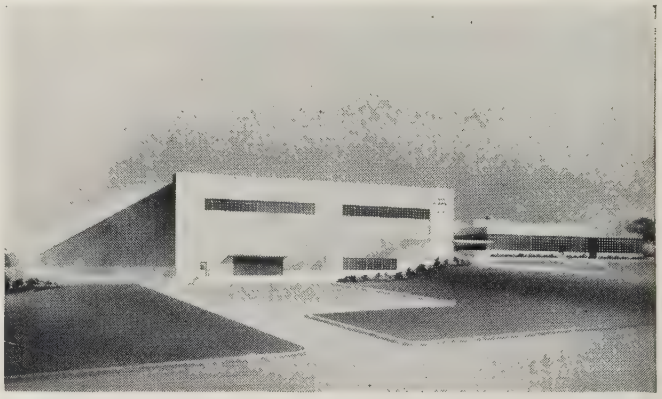

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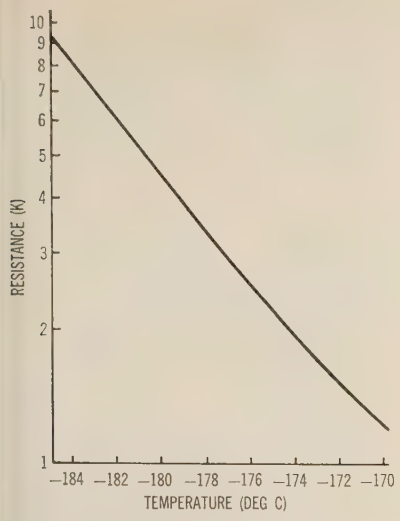

FIGURE 6: Gage current in a two-sensitive-arm bridge for —185 deg C and one winding. In practice, two separate windings must be used.

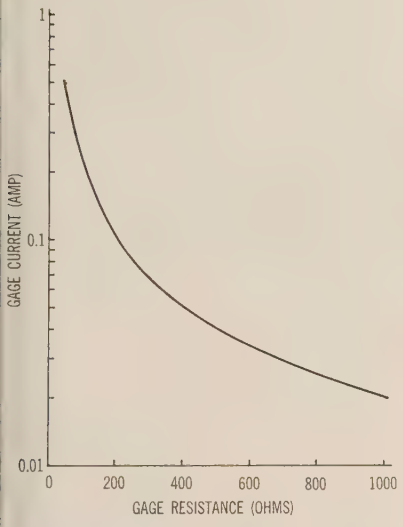

FIGURE 7: Calibration curve for a typical Keystone thermistor.

sistance thermometers may be reconsidered.

Commercial carbon-composition resistors have been studied by the Naval Research Lab for measuring temperatures somewhat lower than those of LOX.[3] A test of such a resistor at LOX temperature gave the data of *Figure 1*.

The use of thermocouples or thermopiles in flight is ruled out because of the very small span of temperature change. In actual practice, a range of only —185 to

(3) J. R. Clement & E. H. Quinnel, "The Low Temperature Characteristics of Carbon-Composition Thermometers;" *Rev. Sc. Instr.*, 23/5 ('52).

more on next page

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Santa Monica, Calif.

Some Temperature Gages for Use in LOX*

Manufacturer	Model	Type
Aero-Research Instrument Co., Inc., 315 N. Aberdeen St., Chicago 7, Ill.	T-1306	Keystone thermistor
Allegany Instrument Co., Inc., 1091 Wills Mountain, Cumberland, Md.	30	platinum resistance thermometer
Arnoux Corp., 11924 W. Washington Blvd., Los Angeles 66, Calif.	7XXXL series	platinum film, Keystone thermistor, platinum resistance thermometer
Astra Technical Instrument Corp., 1132 Mission St., South Pasadena, Calif.	VLT series	tungsten resistance thermometer
Byron Jackson Co., P. O. Box 2017, Terminal Annex, Los Angeles 54, Calif.	TR-3	tungsten resistance thermometer
Cardinal Instrumentation Corp., 4201 Redwood Ave., Los Angeles 66, Calif.		resistance thermometer
Fielden Instrument Div., Robertshaw-Fulton Controls Co., 2920 N. 4th St., Philadelphia 33, Pa.	1857	platinum resistance thermometer
G. M. Giannini & Co., Inc., 918 E. Green St., Pasadena, Calif.	49132	platinum resistance thermometer
G. M. Giannini & Co., Inc., Empire State Bldg., New York 1, N. Y.	A-403-c	Keystone thermistor
Gulton Industries, Inc., 212 Durham Ave., Metuchen, N. J.	A101	Keystone thermistor
Magnetic Research Corp., 3160 W. El Segundo Blvd., Hawthorne, Calif.	90-123-0	Keystone thermistor
Rosemount Engineering Co., 9424 Lyndale Ave. S., Minneapolis 20, Minn.	134D	platinum resistance thermometer
Trans-Sonics, Inc., Burlington, Mass.	1300 series	platinum resistance thermometer

* This table does not represent recommendations on the part of the Army Ordnance Corps.

—170 deg C has been used.

Our work at ABMA has been concerned mainly with resistance thermometers and thermistors. Unamplified as well as amplified systems have been used with each device. Both Redstone and Jupiter now use Keystone thermistors, with the bridge output amplified by a dc amplifier.

Probably the most stable and reproducible measuring device for LOX temperature is the platinum resistance thermometer. It's been very successful in the lab for many years. But, if no amplifier is used, it's hard to get the 0-5-V dc output generally required in telemetry.

There are two ways of approaching this problem: the one-sensitive-arm and the two sensitive-arm bridges. The latter device has greater sensitivity, but less flexibility.

Figure 2 shows the one-sensitive-arm bridge. An equation for its parameters is:

(1) $V_{in}=V_{out}\{[K^2+(1+R_{max}/R_{min})K+R_{max}/R_{min}]/[(R_{max}/R_{min}-1)K]\}$,

where K is the resistance ratio of the bridge's high arms to the fixed low arm; R_{max} and R_{min} are the resistances of the platinum thermometer at maximum and minimum temperature to be measured, respectively; V_{out} is five volts for most missiles; and V_{in} here required power supply.

Figure 3 shows this function graphically, using the case of —185 to —170 deg C with 0-5 V output. The maximum current through the gage is given by:

(2) $I_{gage}=V_{in}/[(1+K)R_{min}]$,

and is shown in *Figure 4* for several values of K.

Figures 3 & 4 show that, if ex-

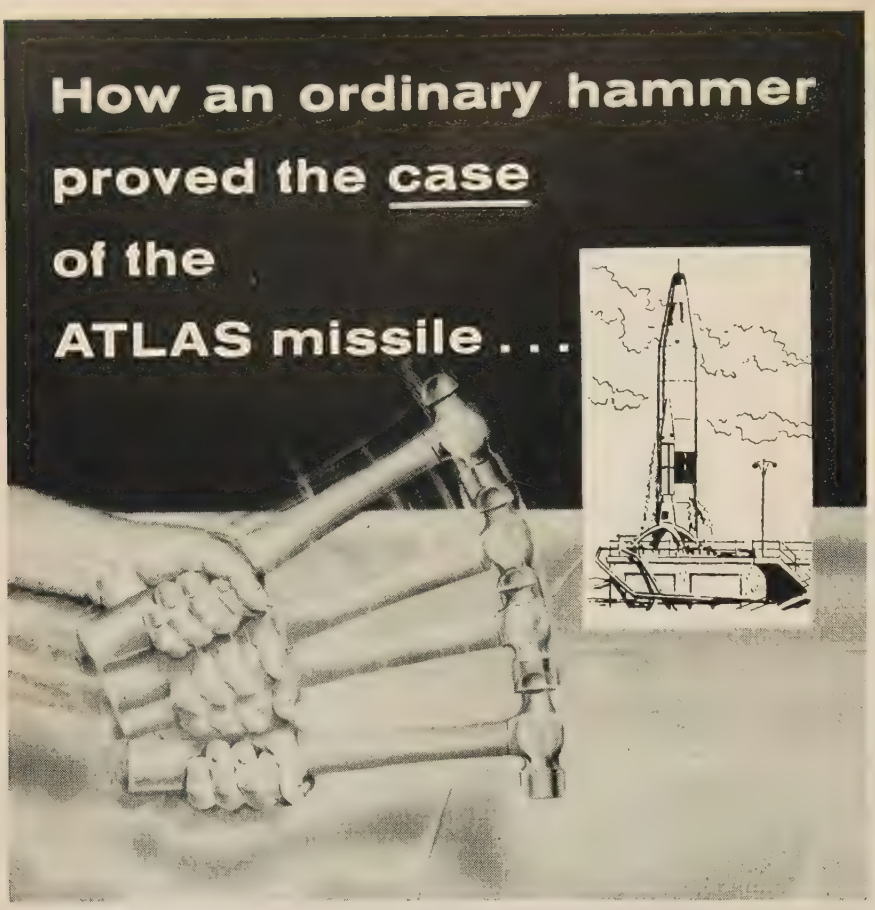
more on page 114

The care and feeding of a missile system

It takes more than pressing a button to send a giant rocket on its way. Actually, almost as many man-hours go into the design and construction of the support equipment as into the missile itself. A leading factor in the reliability of Douglas missile systems is the company's practice of including all the necessary ground handling units, plus detailed procedures for system utilization and crew training. This complete job allows Douglas missiles like THOR, Nike HERCULES, Nike AJAX and others to move quickly from test to operational status and perform with outstanding dependability. Douglas is seeking qualified engineers and scientists for the design of missiles, space systems and their supporting equipment. Some immediate openings are described on the facing page. Please read it carefully.

Alfred J. Carah, Chief Design Engineer, discusses the ground installation requirements for a series of THOR-boosted space probes with Donald W. Douglas, Jr., President of DOUGLAS

MISSILE SYSTEMS ■ SPACE SYSTEMS ■ MILITARY AIRCRAFT ■ JETLINERS ■ CARGO TRANSPORTS ■ AIRCOMB ■ GROUND-HANDLING EQUIPMENT



The body of the missile, essentially one big fuel tank, is similar in principle to an inflated football. Convair-Astronautics broke new ground in missile design by developing a super-strong structure with a comparatively thin stainless steel skin to keep weight to a minimum. This stainless steel skin is so thin that the interior has to be pressurized to preserve the shape of the body as propellants are consumed in flight, or when the missile is being transported on the ground.

Some critics, however, thought the body was too fragile—"You could dent it with a hammer." So, recently, when the Scientific Advisory Board, engaged in a re-evaluation of all missile programs, arrived at Convair-Astronautics to take a reading on the ATLAS, they found that Convair had thoughtfully placed a number of hammers within easy reach of a finished missile. "Go ahead, bash it," invited Convair. The SAB members swung lustily. *Not a dent was registered*, for, although the walls are thin, the stainless has a minimum tensile strength of 200,000 psi.

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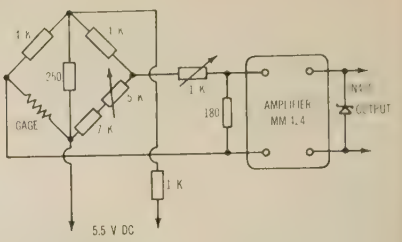

FIGURE 8: Simplified circuit diagram showing the use of a Keystone thermistor in an amplified system. This type of system is used in Redstone and Jupiter.

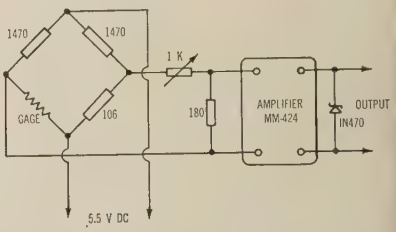

FIGURE 9: Simplified circuit diagram showing the use of a resistance thermometer in an amplified system. Since probe has a fairly linear characteristic, there's no difficulty in getting a linear output.

cessive self-heating current is to be avoided, very-high-resistance gages must be used. The voltage level of the power supply also becomes quite high, an undesirable feature for high altitude flight (because of corona effects). It should be noted that *Equations 1 & 2* are valid only if the impedance of the telemetering or recording equipment is high compared with the other parameters.

Figure 5 shows the two-sensitive-arm bridge. The equations for this device are:

(3) $V_{in} = V_{out}[(R_{max}+R_{min})/(R_{max}-R_{min})]$,

(4) $I_{gage} = V_{in}/(2R_{min})$.

Figure 6 shows the result of *Equations 3 & 4* for the example used in *Figures 3 & 4*. Again it's obvious that the gage resistance must be quite high. It must also be borne in mind that two separate windings are needed in the probe.

A more practical unamplified system involves the use of a thermistor probe. The non-linearity of the thermistor causes no trouble; the output of the bridge used with the Bendix Friez unit is quite linear with temperature. The self-heating effect of current through the ther-

more on page 118

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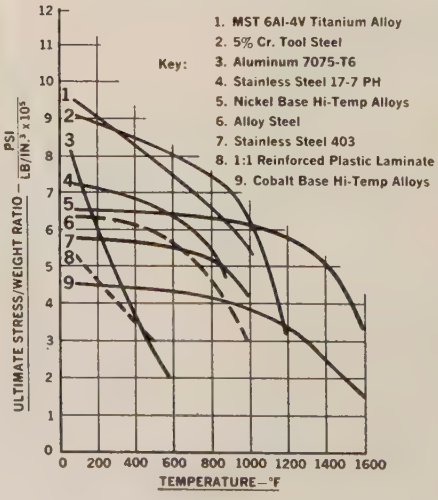
(Test data courtesy of Thompson Ramo Wooldridge)

VARIATION OF ULTIMATE STRENGTH/WEIGHT RATIO WITH TEMPERATURE
(of comparable ductilities)


ULTIMATE STRESS/WEIGHT RATIO — PSI / LB/IN.³ x 10⁵
TEMPERATURE—°F
Key:
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2. 5% Cr. Tool Steel
3. Aluminum 7075-T6
4. Stainless Steel 17-7 PH
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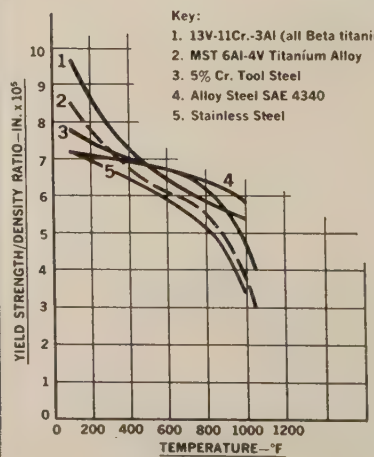

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strength/weight ratio of 960,000

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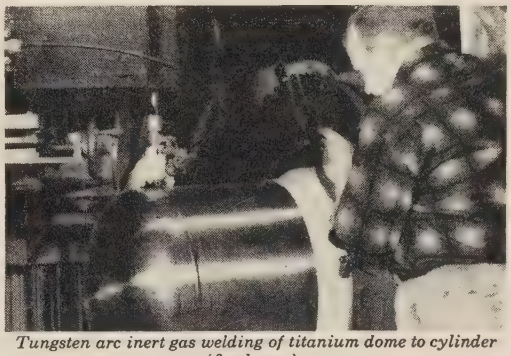
New, advanced type, solid-fuel propellants . . . plus the need to achieve maximum range . . . demand an entirely new look at tensile strength/weight ratios in missile components. For example, designers can no longer tolerate rocket cases whose inert mass approximates 20% of total unit weight. Today's goal: hold rocket-case weight to *less than 10%* of propellant weight.

To achieve this goal, tensile strength/weight ratios of close to 1,000,000 are required in the rocket case. In this range, welded heat-treated steels develop severe embrittlement and high notch sensitivity when subjected to rocket case hoop stresses — largely ruling out their use. Titanium overcomes these disadvantages, plus giving *a weight saving of 25% to 38% over the best competitive steels!*



Tungsten arc inert gas welding of titanium dome to cylinder (final pass).

Extensive development work and testing by the Tapco Group of Thompson Ramo Wooldridge has conclusively proved Mallory-Sharon 6Al-4V titanium alloy to be the most suitable material for this application (see charts at left). It provides the necessary strength and ductility without embrittlement or distortion. It can be readily welded and age hardened to give the welded strength/weight levels required. In view of titanium's outstanding advantages and continuous reductions in cost, any price difference becomes insignificant.

Thompson's excellent experience with MST 6Al-4V titanium alloy enables this leading component parts producer to *guarantee* performance and strength ratios of its titanium rocket motor cases . . . in sizes up to 60″ diameters, 20-ft. lengths.

Here's important proof of titanium's growing advantages in missile applications . . . and of Mallory-Sharon's ability to furnish material to meet the most exacting quality specifications. For technical information or application assistance write to: Aircraft & Missile Development Dept., Mallory-Sharon Metals Corporation, Niles, Ohio.

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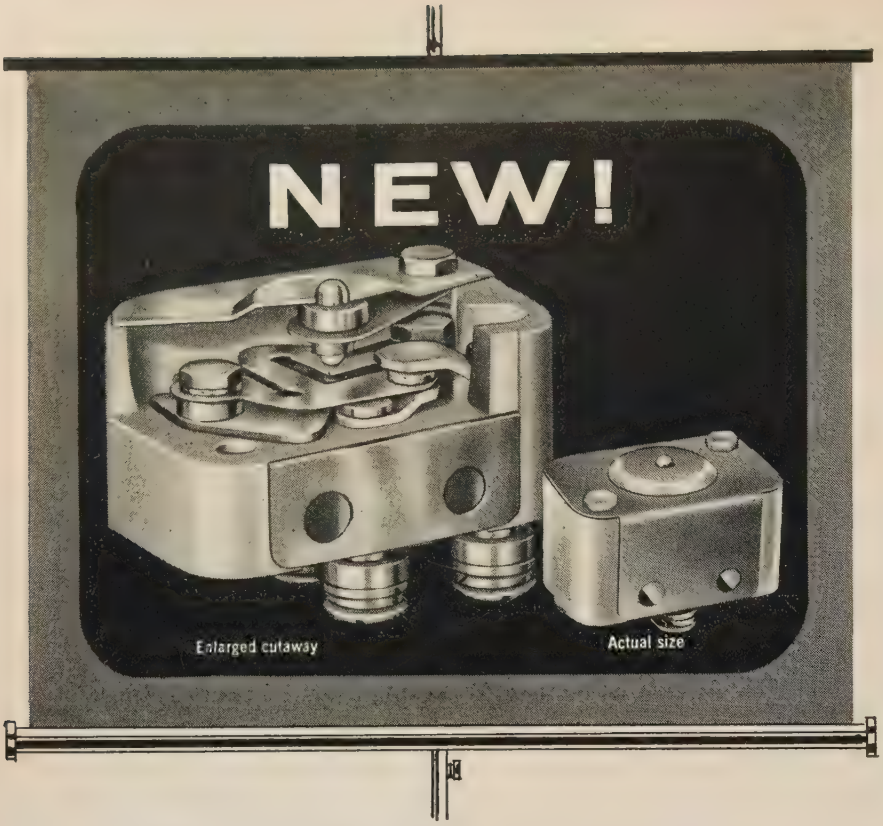

High Temperature KLIXON PRECISION SWITCH

Operation you can rely on even at 800°F.

Maintains operating characteristics at maximum temperature — Will not lose its snap action, "skip," or fail to actuate at 800°F.

"Surity-of-make" with dry circuit applications — Completely inorganic components mean no contact surface contamination due to out-gassing of organics at high temperatures.

Saves space and weight — Miniature size . . . weighs about an ounce.

Designed specifically for high temperatures — Means no compromise with operating characteristics, such as life expectancy, caused by modifying an existing design into a high temperature model.

Assured longer life expectancy — Over 25,000 cycles at 800°F. The simple, one-piece sine blade eliminates knife edges and high friction points.

OTHER OPERATING CHARACTERISTICS

Movement Differential	0.005", max.
Release Force	0.2 lbs., min.
Operating Force	0.5 to 1.5 lbs.
Current Rating	5 amperes, 30 VDC, resistive
Contact Arrangement	S.P.D.T.
Vibration Resistance	20 G's, 25 to 2,000 CPS
Shock Resistance	100 G's

For more information on the new KLIXON High Temperature Precision Switch, write for Design & Development Bulletin, DD-PRSW-9.

Western Manufacturers — refer inquiries directly to Metals & Controls' Southern California Office . . . 232 North Lake Avenue, Pasadena, California . . . Telephone: Ryan 1-4288.

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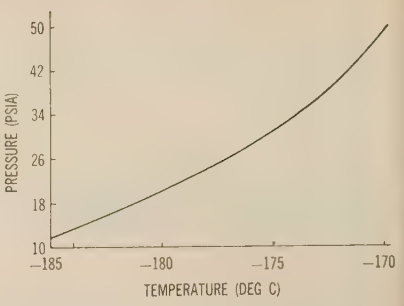

FIGURE 10: Oxygen vapor pressure vs temperature.

mistor is large enough to be troublesome, and it takes some effort to calibrate it out.

As can be seen, each unamplified system has certain disadvantages. For Redstone and Jupiter, a very satisfactory amplified system has been developed that will handle thermistors, resistance thermometers, thermocouples, or thermopiles.

Unfortunately, the impedance of the Bendix Friez thermistor was too high for this system. In 1956, Keystone Carbon was able to recommend a thermistor with the characteristic shown in *Figure 7*.[4] This unit fitted well into the amplified system (*Fig. 8*).

Again the system output is quite linear in spite of the logarithmic characteristic of the thermistor. The self-heating current has little effect. These new thermistors are somewhat more closely matched than those previously obtainable.

In an amplified system, resistance thermometers can be used that do not have high impedance (*Fig. 9*).

Probe calibration has followed the method suggested by Martin. A container is used with provision for mounting 10 probes. It's filled with LOX or liquid nitrogen and capped. The vapor pressure is monitored by a dial manometer and controlled by a manually operated needle valve.

The gage pressure readings are converted to absolute pressure by reference to a barometer. Probe resistance is read by means of a Wheatstone bridge using conventional methods. *Figure 10* plots oxygen vapor pressure vs temperature. Tests have proved this method accurate to 0.25 deg C.—End

(4) H. B. Sachse, "Low Resistance Thermistors as Ultra-Cold Thermometers;" *El. Ind. & Tele-Tech*, Jan. '57. "Temperature Measurements near Absolute Zero;" *El. Ind. & Tele-Tech*, Sept. '57. "Design Data for Ultra Low Temperature Thermistors;" *El. Des.*, Apr. 30, '58.

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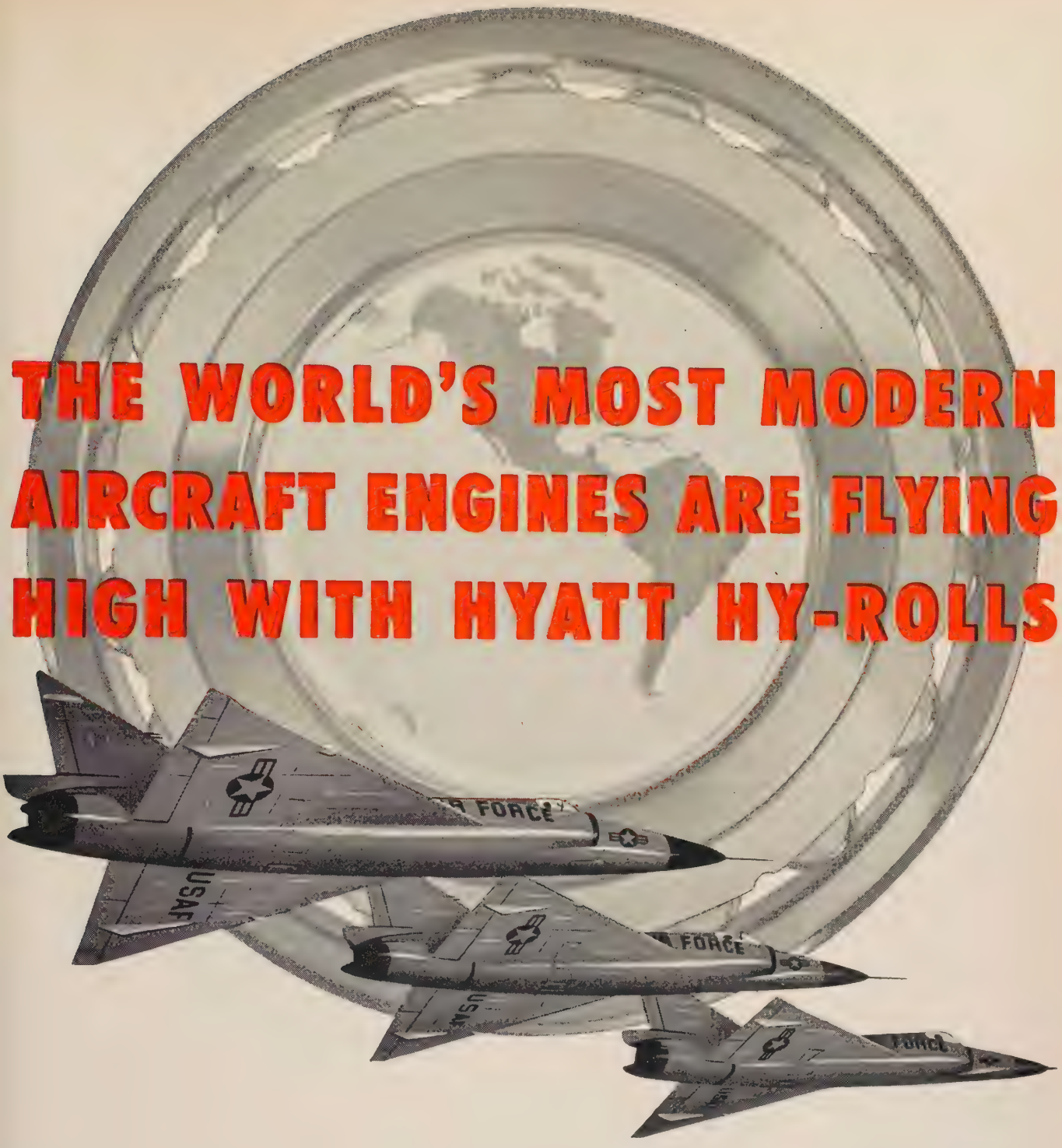

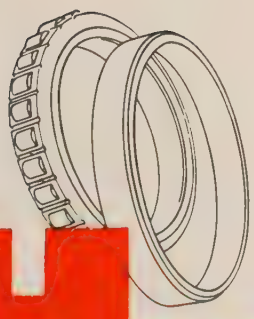

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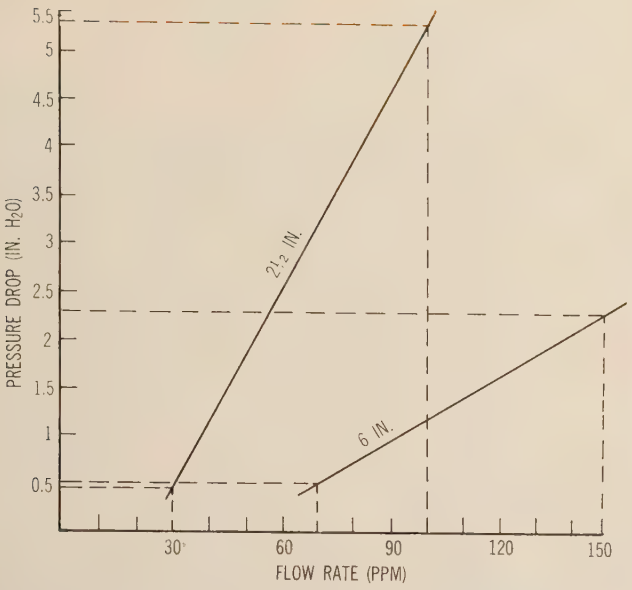
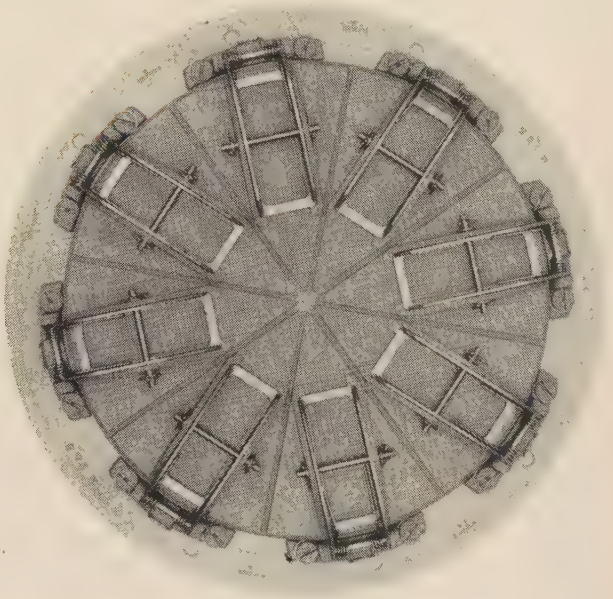


FIGURE 2: Performance of 2½- and six-inch multi-flapper valves.

FIGURE 1: New valve designs use up to eight flappers.



Multi-flapper check valve cuts weight, ups performance

If you want to cut down on pneumatic system weight, you might be able to do it with multi-flapper valves. The dynamic forces in them are much lower than in equivalent single-flapper designs, and so lightweight materials and structures can be used.

by Arnold A. Cowan, Vice President,
Bobrick Manufacturing Corp.*

THE secret of multi-flapper valve design lies in reducing the effects of system forces on the valve elements. The results are an appreciable improvement in performance over single-flapper valves and significant savings in envelope size and weight.

The kinetic energy of a flapper in motion can be expressed by:

$$KE = mv^2/2g,$$

where m is mass (in pounds); v, linear velocity (in fps); and g, acceleration of gravity.

The linear velocity equals the product of the flapper radius (r, measured in feet from the hinge point to the center of mass) and the angular velocity (in rad/sec). Obviously any shortening of r reduces the velocity.

* Bobrick Manufacturing Corp., 1840 Blake Ave., Los Angeles 39, Calif.

more on next page

FOR AIR TRAFFIC CONTROL

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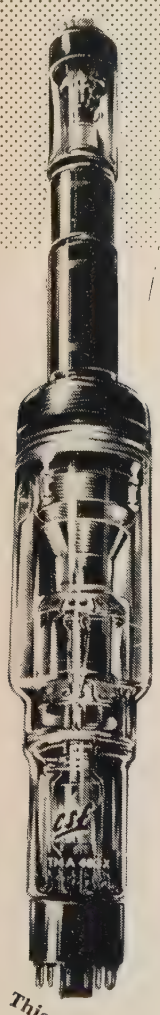

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various service informations,
labelling aircraft, outlining geographical features.

by **making it possible to transmit**
the complete radar picture,
over coaxials
or long distance microwave links,
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Civil and military applications

This tube was developed and manufactured by

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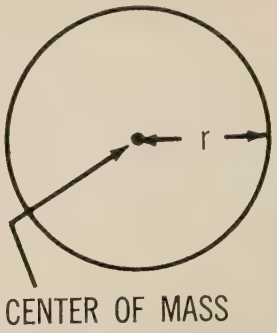


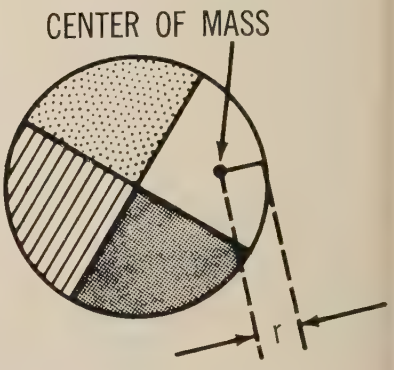


FIGURE 3: Center of mass of each segment of a four-flapper check valve (top) is about one-third closer to the hinge point than that of a single-flapper design (below).

Since the kinetic energy varies as the square of the velocity, such a reduction is more effective than any reduction of the mass.

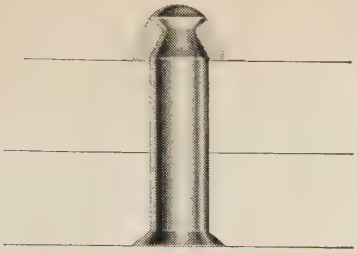
This effect is probably best shown by a comparison of a single-flapper check valve (hinged at the periphery) with a four-flapper valve (*Fig. 3*). The center of mass in each of the four individually hinged flappers is about one-third closer to the hinge point than in the single flapper.

For a given set of dynamic conditions, the velocity of one segment of a four-flapper valve will be one-third as much as that of a single-flapper valve. Assuming the mass of each segment equals one-fourth of the mass of the single flapper, we have, for one segment:

$Ke = m/4(v/3)^2/2g = mv^2/72g.$

Each segment of a four-flapper valve experiences about $\frac{1}{36}$th as much kinetic energy as an equivalent single-flapper design. Such a drastic force reduction makes it

more on page 124



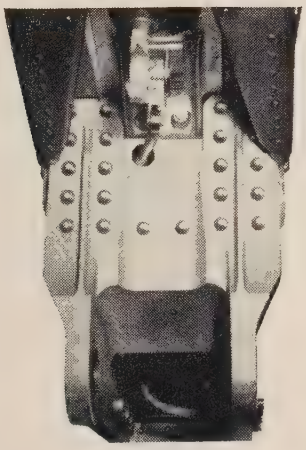
F4H-1 STRUCTURE AGAIN PROVES *hi-shear* RIVET VERSATILITY

The Navy's next generation fighter...the McDonnell F4H-1 flies at better than twice the speed of sound, has a greater range than any Navy turbojet fighter and can operate day or night in any weather as an interceptor in an attack role.

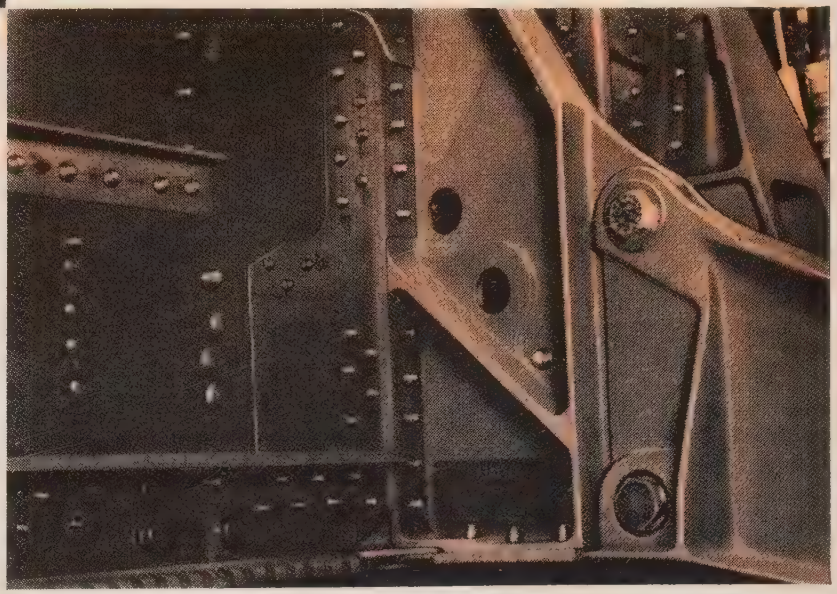
Structurally, the F4H-1 posed a variety of critical fastener problems... high strength/min. weight requirements, elevated temperatures in structures adjacent to the two J79 engines and afterburners, compactness of forging and fitting design, fatigue and vibration conditions... all met by Hi-Shear rivets, extensively used throughout the fuselage, wings and empennage.

The Hi-Shear rivet, service proven over the years in high performance aircraft and missiles, can answer similar problems for you... match the weight and installed cost of the Hi-Shear rivet with any other comparable swaged fastener.

Today Hi-Shears can meet temperatures to 1200° F., are available in sizes from 1/8 thru 5/8 diameters and come in materials including 7075-T6, alloy steel titanium, 5% chrome die steel, A286 alloy along with 431, 302 and 17-4PH stainless.



ATTACHING THE ARRESTING HOOK FITTING TO THE KEEL ARE TYPE 431 STAINLESS STEEL HI-SHEAR RIVETS, HEAT TREATED TO 125,000 PSI SHEAR, WITH DIAMETERS TO .0005 TOLERANCE. WHILE SUBJECTED TO 600° F. ENGINE TEMPERATURE ON THE F4H-1, THESE RIVETS HAVE A USEFUL RANGE TO 900° F. HI-SHEARS IN OTHER MATERIALS ACCOMMODATE TEMPERATURES UP TO 1200° F.



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hi-shear RIVET TOOL COMPANY

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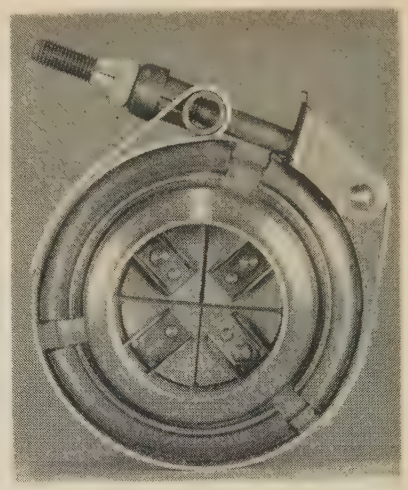
possible to use lighter members and materials.

Early multi-flapper designs used two flappers; some of the newer valves under development have four, six, and even eight flappers hinged along the periphery of the valve (*Fig. 1*). Typical valves range from 1½ to eight inches in diameter. They are designed for efficient operation from —65 to over 1000 deg F under the conditions of vibration, humidity, and environment specified in Mil-E-5272A. The life of a typical stainless steel multi-flapper valve under such conditions exceeds 50,000 cycles. In other, comparably rigorous applications, aluminum valves are good for more than 20,000 cycles.

Because each self-actuated flapper moves away from and out of the center of the fluid stream, the pressure drop in operation is exceptionally low. Flutter loads and other destructive forces on the flappers are also eliminated.



RECENTLY developed multi-flapper inserts save system weight.

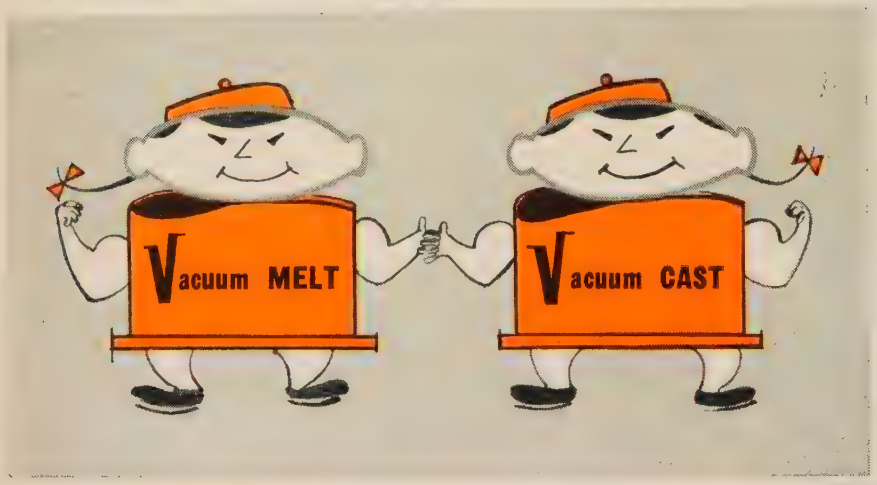
Leakage Characteristics of Multi-Flapper Valves

Valve Size (in.)	Flappers	Back Pressure (psi)	Leakage (ppm)
4	4	15	0.016
2½	6	200	0.19
6	4	15	0.01
3½	2	200	0.05

Pressure drops as low as 7.1 per cent of the velocity head pressure at an air flow rate of 70 ppm are typical for a 3½-in. duct valve operating at 900 deg F. A six-inch valve with a flow rate of 140 ppm introduces a pressure drop into the air duct that is equivalent to less than two inches H_2O.

Figure 2 shows a performance curve for a 2½-in. multi-flapper valve designed for a severe engine-bleed application. Although the spec allowed a pressure drop of 22 in. H_2O at a flow of 100 ppm, the actual maximum was 5.4 in.

Recently the multi-flapper principle has been applied to the development of insert-type valves. As it eliminates large valve bodies, the valve insert substantially reduces the total weight of airborne pneumatic and fuel systems. It can be used with any component that can serve as a valve housing, and it can be combined with most of today's standard clamps and duct connections. Write in No. 71 on Reader Service Card for more information.—End



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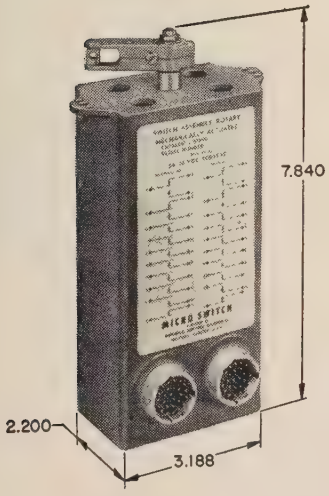
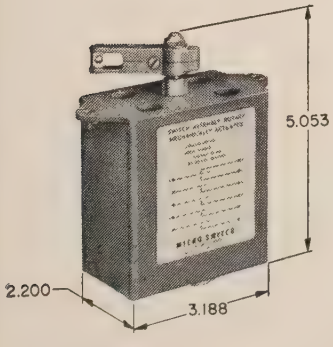
Multiple switch assemblies for aircraft applications



Series "2EK" 20-pole switch assembly



Series "1EK" 5-pole switch assembly

MICRO SWITCH not only offers aircraft designers precision switches of the utmost dependability . . . but provides them in compact assemblies to meet specific multiple circuit requirements.

The "EK" Series, two of which are shown here, is typical of this MICRO SWITCH skill in providing a complete package ready to install.

These "EK" assemblies, one a 20-pole and the other a 5-pole, have proved invaluable in aircraft armament applications. They are compactly wired to standard connectors. Circuits are plainly marked, and the assembly sealed in an environment-proof housing. Switch assemblies shown are operated by positive-drive, non-spring return rotary levers. These assemblies have close-tolerance on-off action. Height of the larger 20-pole switch is only 7.840″ which permits mounting in small space.

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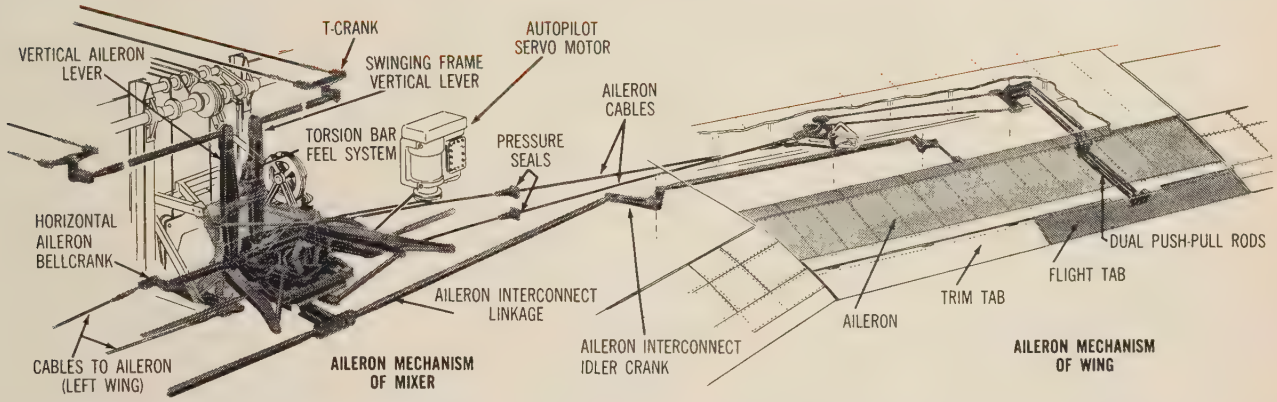
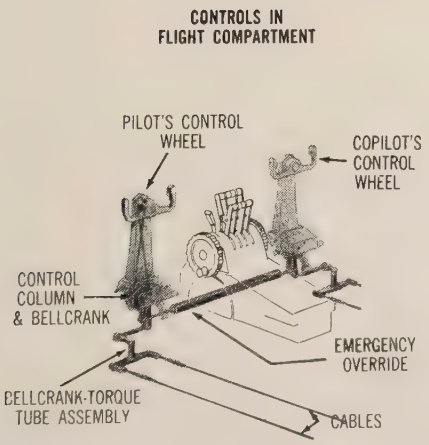


AILERON control system, including aileron mixer mechanism and controls in the flight compartment (below). The mixer design is strictly mechanical—levers, bellcranks, etc., represent the only moving parts.

Jetliner wing features

"push-button" control



Our new jet transports mark the beginning of the switch to "push-button" flight with control surfaces deflected by such means as hydraulic power. On the Convair's 600 and 880, for instance, hydraulically powered spoilers supply most of the roll control, this report shows.

by Hugh R. Smith, Engineering Writer, Convair-San Diego*

THE Convair 880 and 600 have to be able to fly at Mach 0.9 and faster and to take off from and land at any airport now served by four-engine transports. These requirements essentially determined the design of the airliners.

The 600, which is larger than the 880, has more wing surface. Its wing box section, closely similar to the 880's, is about 25 in. larger along the trailing edge. The 600 wing also has anti-shock bodies on the upper surface. These are two contoured, faired-in pods whose

more on next page

* Convair Div., General Dynamics Corp., 3165 Pacific Highway, San Diego, 12, Calif.

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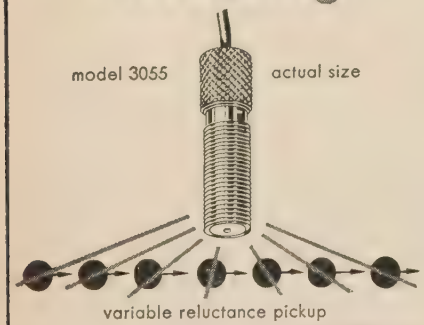

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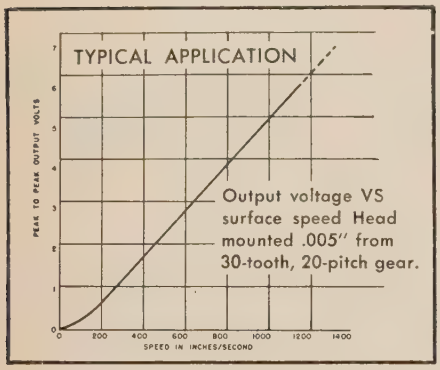
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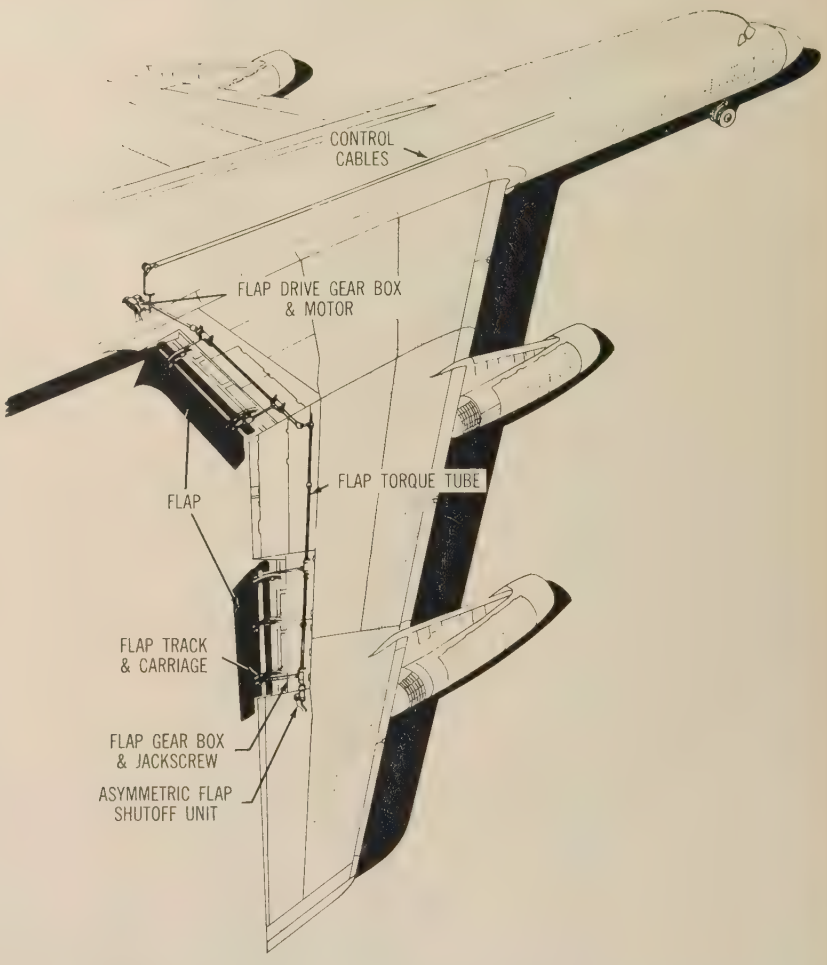

FLAP CONTROL system for Convair 600 and 880 uses a central gear box for direct manual control of the hydraulic selector valve. Two hydraulic motors—one for each hydraulic system—are coupled to the gear box.

aerodynamic function is based on the "area rule". They required a distinct spoiler design; however, aileron, spoiler, and flap operations are the same on both the 600 and the 880.

"Push-button-flight line" reached at Mach 1

Mach 1, the so-called "sound barrier", might also be termed the "push-button-flight line". Beyond Mach 1, control surfaces can't be deflected by direct manual means, so hydraulic power is generally used. In the 880-600 design, the pilot still moves the rudder, elevator, and ailerons directly by cable-and-bellcrank linkage to flight tabs.

The lateral control system, however, represents a compromise with "pushbutton" flying. The ailerons have dropped to a secondary role. They provide a manual backup for flying the plane in an emergency on pilot feel and trim. Hydraulically powered spoilers furnish about two-thirds of the roll control. This arrangement is needed because of the greater wing loads at high speeds and the characteristics of the 35-deg swept wing.

Ailerons used to be placed outboard, so that they would be more effective in roll control with minimum drag. However, at high Mach numbers, a wingtip aileron may function as a flight tab—it may produce a torque moment large enough to twist the wing tip to the point of control reversal. This effect is aggravated by sweepback.

Our design criterion was that enough lateral correction and sufficiently sensitive control should be provided for landing in a 25-knot crosswind. The necessary roll mo-

more on page 130

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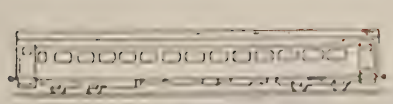

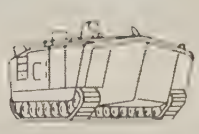

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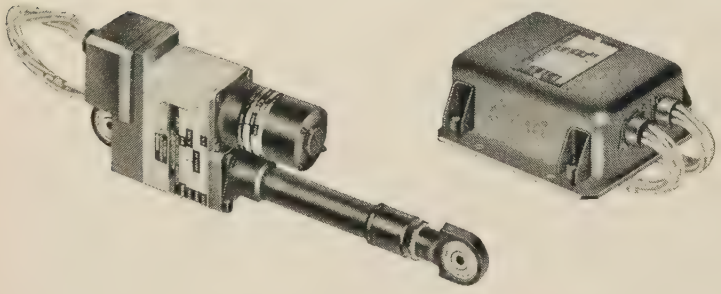
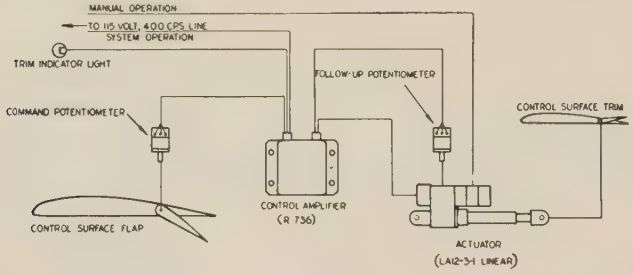
AIRBORNE

electromechanical system provides automatic trim control for T-38



Schematic diagram shows Airborne automatic horizontal stabilizer trim control system on Northrop T-38 Talon. Control is achieved by d-c signals from 1000-ohm potentiometer on flap and followup from similar potentiometer on actuator. System functions only when flaps are lowered, with signal light indicating completion of adjustment for flap position selected.



Automatic horizontal trim control on Northrop's T-38 Talon high-performance jet trainer is provided by an Airborne electromechanical system comprised of an electronic control amplifier and an Airborne modular-type linear actuator. The system functions when the flaps are in use. At other times, the actuator is manually controlled by the pilot.

Sealed relays especially selected for their reliability characteristics are used in the output stage of the amplifier to control the 115-v, 400-cycle supply required by the brake-equipped actuator. The step function thus provided assures positive release of the actuator brake.

Control is simply achieved by d-c command signals generated by a 1000-ohm potentiometer on the wing flap and followup from a similar potentiometer on the actuator. Hysteresis of the control circuitry is deliberately broad to preclude hunting.

The entire system is designed for extreme compactness and light weight. The actuator is the smallest of Airborne's modular-design series, weighing only 1.4 lb., yet providing 75 lb. output. The control box measures only 1.6 x 4.2 x 3 in. and weighs just 1.2 lb.

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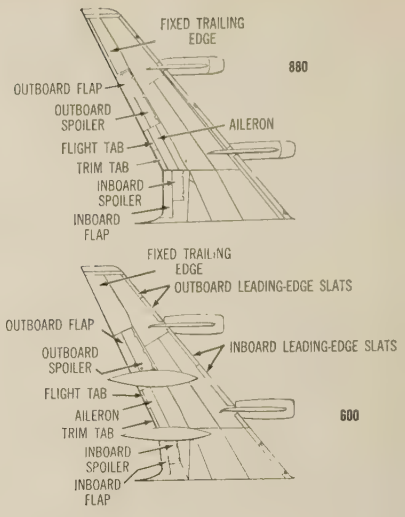


WING control surface locations for 600 and 880. Note the two contoured anti-shock pods on the 600 wing.

ment is more than you can get with ailerons alone, particularly when they're brought inboard far enough to eliminate control reversal.

Spoilers give the needed roll moment

Spoilers are therefore used together with the ailerons. They are over two feet wide and can be extended to 60 deg trailing-edge up at any speed up to 200 knots IAS. They extend fully in two seconds; retraction is even faster. In a second function, the spoilers are also used for speed braking.

The 880 obtains drag both from spoiler action and from the main landing gear, which may be lowered independently of the nose gear. The 600 uses only the spoilers. These operate differentially in roll control and simultaneously and symmetrically in speed braking. The control column operates ailerons and spoilers together for lateral control; speed brake control is provided by a lever on the pedestal.

The high force needed to operate the spoilers is provided by hydraulic piston actuators powered by both the plane's 3000-psi hydraulic systems. There are two spoilers on each wing, one inboard of the aileron and another, two-section unit outboard. Each of the three sections has two actuators, with one dual selector valve

more on next page

for the inboard spoilers and another outboard. Mechanical follow-ups stop the flow to the actuators when the selected spoiler position is reached.

The valves are designed so that there's always some flow through them, permitting reverse flow from the actuators if aerodynamic loads are too great. In this case, the spoilers will partially blow down. Should one hydraulic system lose pressure, the hinge moment will be reduced and the blowdown increased, but full deflection will still be possible at 150 knots IAS or less.

Lateral control overrides speed brake control

Lateral control is always superimposed on speed brake control, regardless of the speed brake setting. With the speed brakes closed and as an aileron moves up, the spoiler on that side moves up, too. With the spoilers full open, the one on the down-aileron side retracts. At any intermediate setting of the speed brake lever, one spoiler moves up and the other down.

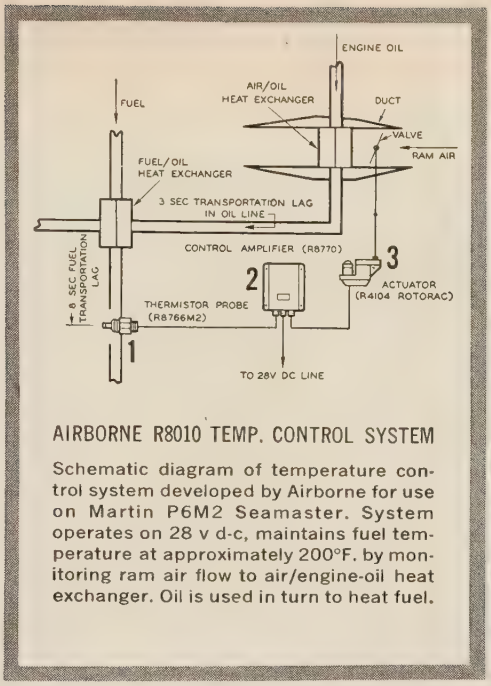
Blowdown protection in the selector valves makes it possible to extend the spoilers at any speed. An indicator beside the speed brake control lever marks the speeds at which blowdown from speed brake setting may be expected. A feel spring provides control lever resistance that increases with spoiler deflection.

Simple interconnection of two systems

The lateral and speed brake control systems are interconnected through a single, compact unit—the aileron-spoiler mixer assembly in the hydraulic compartment between the wings. This mixer receives inputs from the control wheels, the speed brake control lever, and also from an autopilot mounted nearby. From it, cables run through the wing trailing edge to operate the aileron flight tabs, and a push-pull linkage runs to the selector valves for spoiler operation.

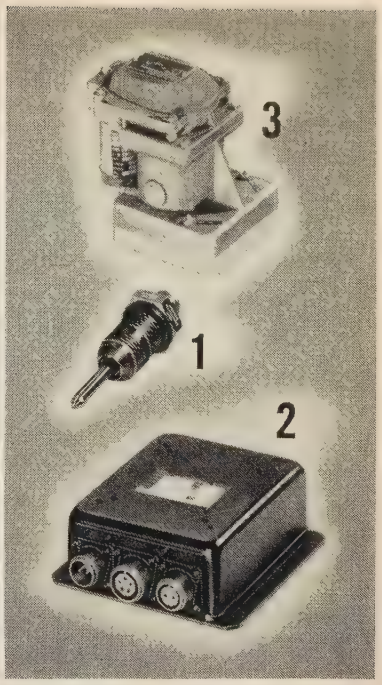
Direct aileron control is used. As they are turned, the pilots' control wheels actuate push-pull rods and bellcranks that are located under the flight deck and interconnected between the control wheels.

more on page 133



AIRBORNE R8010 TEMP. CONTROL SYSTEM

Schematic diagram of temperature control system developed by Airborne for use on Martin P6M2 Seamaster. System operates on 28 v d-c, maintains fuel temperature at approximately 200°F. by monitoring ram air flow to air/engine-oil heat exchanger. Oil is used in turn to heat fuel.



Airborne electromechanical system regulates jet fuel temperature

An integral part of each main engine installation on the Martin P6M2 Seamaster is an Airborne R-8010 custom-engineered temperature control system. By regulating air flow through a heat exchanger, this system maintains supply line fuel at 180-220°F.

As developed for the P6M2, the R-8010 system consists of a thermistor probe, a control amplifier and a rotary actuator. The probe (mounted in an MS10057-12 fitting) is in direct contact with the temperature-regulated fuel and presents to the control box a resistance which is proportional to fuel temperature. In response, the control box energizes the actuator to change the setting of a ram air intake valve, thus regulating volume of air flow through an air/fuel heat exchanger. This sensing and response continues until prescribed fuel temperature is attained, at which point the system reaches a state of electrical balance.

A fail-safe feature is also provided. In the event of power failure, a magnetic clutch in the actuator is released, permitting the air valve to be pushed open by the force of the ram air.

This application* on the P6M2 illustrates only one of many possible adaptations of the Airborne R-8010 system for temperature control functions on aircraft, missiles and related equipment—cabin temperature control, engine temperature control, temperature regulation of fuel, oil, electronic cooling packages, etc. If you have requirements in these areas, we will be happy to make a proposal. Contact any of our offices.

*Described in detail in new Bulletin PS-4A, available on request.

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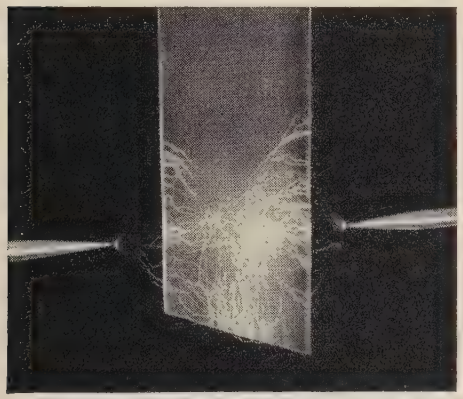

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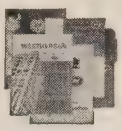

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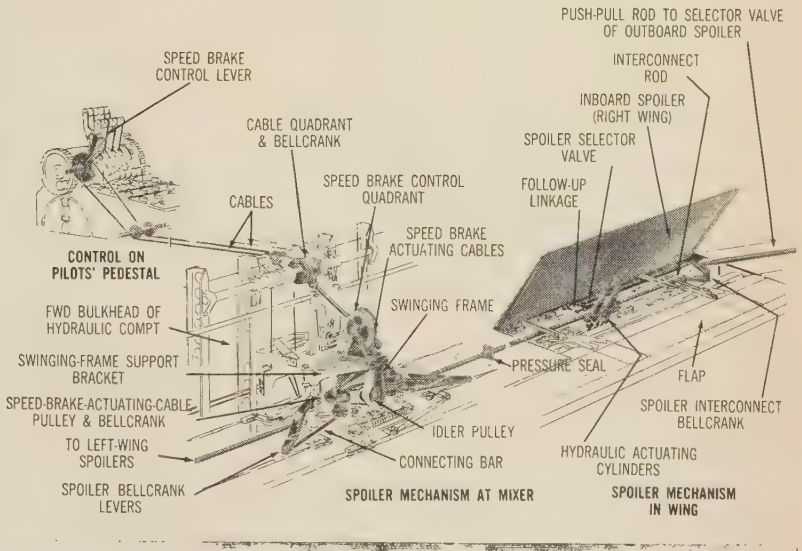

SPOILER CONTROL system. Each wing has one spoiler inboard of the aileron and a two-section outboard spoiler.

A pair of cables on each side transmits the movement aft to T-cranks at the mixer. Only the T-crank on the pilot's side is connected to the aileron control. The co-pilot's aileron control is exercised through the interconnect between the control columns.

Push-pull rods, cranks, and levers transmit the motion to cable bellcranks from which cables pass through the wings to the aileron. Dual push-pull rods move the flight tab horn by means of bellcranks at the aileron and tab hinge lines. The trim tab is operated conventionally by cables connecting it directly to screwjack actuators.

Aileron control is reversible, so that aerodynamic forces acting on a tab are transmitted back through the mixer to the control wheels. A torsion bar in the mixer adds to pilot feel and acts as a centering spring. To maintain equal surface displacement, the ailerons are interconnected by a push-pull rod linkage.

Swinging frame provides the interconnect

The pilots' speed brake handle operates cables connected to a bellcrank near the mixer. A rod connecting the bellcrank to the mixer operates a closed cable-and-quadrant system. Two quadrants, mounted on a swinging frame, actuate levers that operate the push-pull rods leading to the spoiler selector valves in the wings.

When the swinging frame is stationary, moving the speed brake control lever rotates the quadrants an equal amount, but in opposite rotation. This causes the selector valve linkages in each wing to move simultaneously either outboard or inboard, moving the spoilers up or down in unison.

Swinging frame connects aileron, spoiler

Aileron and spoiler are interconnected through the swinging frame. Cables from the copilots' control wheel run to a T-crank that is mechanically linked to the frame. When the wheel is turned, the frame pivots. Selector valve linkages are moved simultaneously right or left, causing one spoiler to move up and the other to move down.

We now can see how the mixer programs spoiler displacement with reference to the aileron input regardless of the speed-brake setting. Whatever the angular position of the quadrant that governs speed brake operation, the pivoting of the frame will move the spoiler linkages in the direction of more displacement on one side and of less on the other.

The selector valves allow an unusual amount of over-travel. Differential spoiler operation therefore is possible with the speed

more on next page

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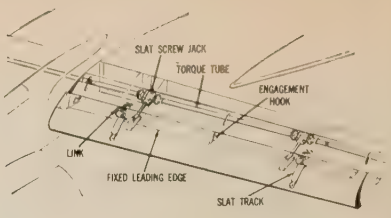

LEADING-EDGE slat control system for the 600. Each wing has four slats. Each slat is extended by two screwjacks operated by a torque tube assembly that's turned by dual hydraulic actuators at the plane centerline. The slats move forward and then down in a 15-deg rotational movement.

brakes closed or fully extended. The movement of the linkages may affect flow through the valves in only one wing.

Double-slotted Fowler flaps are used

The autopilot input goes to the linkage between the right-hand T-crank and the swinging frame. It thus operates the spoilers directly but the ailerons more remotely—via the cables to the flight compartment and back through the left-hand pilot's control cables. Irreversible mechanisms keep the aileron movement from changing the speed brake settings and the speed brake feel spring from retracting the spoilers.

In the standard 880, the flaps provide the necessary low takeoff and landing speeds. They are double-slotted Fowler types, one inboard and one outboard of the aileron. Maximum extension is in an arc to about 50 deg downward. They're extended by screw-jack mechanisms, all of which are operated through torque tubes by a central gear box at the fuselage center.

On the larger 600, added lift for landing's provided by leading-edge slats. Slats are also used in the longer range version of the 880, which can carry an additional 20,000 lb of fuel.

The same pilot control lever operates both flaps and slats. Slats extend when the flaps reach a certain position. Cables from the flap control also operate a dual-selector valve for the slat motors. There's no intermediate setting—the slats are either fully retracted or extended.—End

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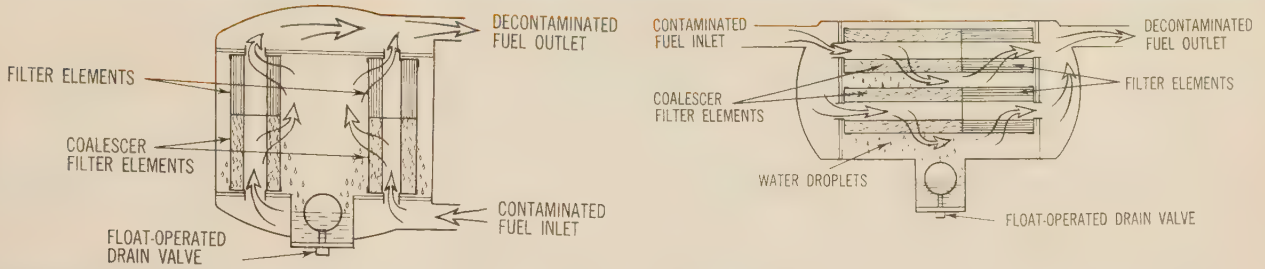

FIGURE 1: Filter-water separators using two filtering systems can be mounted vertically (left) or horizontally (right). Designs using separate arrays of systems are also possible.

New jet fuel filter-separators feature automatic cutoff

Fuel contamination by dirt, water, or ice is the biggest single cause of jet engine failure today. Such failure can be prevented by sound filtration methods on the ground and in the air.

by Walter Kasten, Chief Engineer, Bendix Filter Div., Bendix Aviation Corp.*

JET fuel is produced at the refinery to rigid specs. It is practically free of solid contamination and water. However, because it has a high affinity for water, some water will dissolve in it.

The amount of water that will dissolve in fuel increases with the fuel temperature. When the temperature drops, undissolved water appears. An overnight drop in fuel temperature from 50 to 10 deg F produces one gallon of undissolved water in a 20,000-gal tank.

While the fuel is stored, the undissolved water causes rusting of some of the iron with which it comes in contact. Condensation of moisture from the air (caused by temperature changes) continually adds water to the fuel. And dust gets into the fuel through the vents of the storage tanks. During transfer and shipping, more contaminants are added, especially particles worn from pumps, bearings, and packings. By the time it is pumped into the aircraft fuel tank, the once clean fuel is thoroughly contaminated.

At the fuel consumption and operating altitudes of our jet aircraft, this contamination causes serious problems. At high altitudes, for instance, temperatures are low enough to cause malfunctions due to freezing water in the fuel. Also, it's no longer true that solid contaminants are not harmful if none is larger than the smallest clearance in the fuel control system.

Fuel controls now handle tens of thousands of gallons per flight. With such huge quantities of fuel, a large number of small particles can be even more harmful than a small number of large particles. These small particles accumulate in dead end passages or cause silting in delicate servo mechanisms.

A fuel control cannot digest large quantities of dirt. It only

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Printed circuit cards by PHOTOCIRCUITS have *plated-thru holes* that help eliminate troublesome intermittents caused by vibration and temperature changes... increase solderability, too.

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"Bonus" copper, on the right-size hole wall, is just one of the reasons you can depend on PHOTOCIRCUITS printed circuit cards. Proper design, precision production, and advanced quality control techniques are others. All add up to outstanding reliability... often at lower cost.

Check the advantages of printed circuit cards with *plated-thru holes* by PHOTOCIRCUITS... the largest and most experienced manufacturer in Printed Circuitry. For full information, write our Engineering Department PS-1 today.

PHONES
GLEN COVE 4-8000
FLUSHING 7-8100
CABLE
PHOCIRCO

Photocircuits
CORPORATION
GLEN COVE, NEW YORK

Write in No. 114 on Reader Service Card at start of Product Preview Section

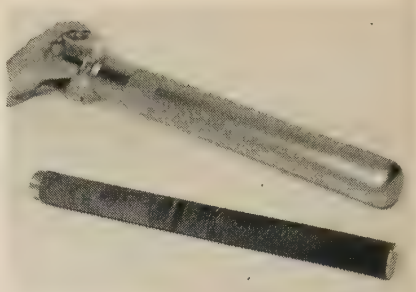


FIGURE 2: Cutoff filters, rated at two microns, are similar to this one used to filter hydraulic fluid on missile test stands.

passes it on to the nozzle strainers —and plugged nozzle strainers have caused many flameouts. Even if there is no serious mishap, contamination increases wear and reduces service life.

Two systems enclosed in one housing

Obviously, fuel filtration is needed to overcome the contamination. The most satisfactory type of unit for this job, experience has shown, is a combination fuel filter-water separator. Such a unit can provide fuel with average solid impurities of less than ¼ gm per 1000 gal.

A typical water separator for providing jet fuel of maximum cleanliness and freedom from water uses two separate filtering systems enclosed in a single vertical or horizontal housing (*Fig. 1*). The first system has a "coalescer" filter element. This element is a specially treated blanket of densely compressed layers of special fine glass fibers wrapped around a pleated, phenolic-resin-impregnated cellulose filter media.

Water carries off the traces of solids

Flow is from inside to outside. Solid contamination is retained on the inside. As the fuel flows through the glass fiber part of the element, water, having a natural affinity for glass surfaces, collects on the fibers in small particles. These combine into large droplets that settle into the filter sump. Traces of extremely fine solids are carried with the droplets into the sump, from which the mixture is discharged through a float-controlled drain valve.

The coalescing system is wholly

more on page 140

Tiger Brand—America's No. 1 Control Cable

Boeing 707 flies like a bullet —handles easily with Tiger Brand Control Cables

Six miles up, the Boeing 707 carries 160 passengers more than 600 miles an hour. She's fast, comfortable and safe because the control cables were designed by American Steel & Wire to meet the most rigid specifications. These cables have high strength, high resistance to bending fatigue, minimum stretch and maximum flexibility.

Tiger Brand Control Cables are used on all types of aircraft, from small commercial planes to the heaviest bombers. There is the *right* control cable for you.

For more information write to American Steel & Wire, Dept. 9232, 614 Superior Avenue, N.W., Cleveland 13, Ohio.

USS and Tiger Brand are registered trademarks

Why Tiger Brand Control Cables are your best buy

1. They are made by a company that maintains the most complete wire rope research and manufacturing facilities in the country.

2. They are designed by one of the country's most capable staffs of wire rope engineers. They are serviced by thoroughly experienced field representatives always ready with their assistance.

3. Every type of Tiger Brand Control Cable is designed for specific applications. You get the *right* cable for the job.

4. They are made by *one* company, U. S. Steel, and every step of production, from ore to finished product, is carefully controlled and supervised to guarantee *one* high standard of quality.

5. Tiger Brand Control Cables are manufactured by the largest single producer in the country.

American Steel & Wire Division of United States Steel

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors
Tennessee Coal & Iron Division, Fairfield, Ala., Southern Distributors
United States Steel Export Company, Distributors Abroad

Write in No. 115 on Reader Service Card at start of Product Preview Section

self-sufficient. It can provide clean, water-free fuel under normal operating conditions.

To get maximum operating safety, the fuel is passed through a second system that has a filter element of either the resin-impregnated, pleated-cellulose or the "stacked"-washer type. This system in itself also can reject all water droplets and retain solid particles and backs up the coalescer element as a final filter.

The choice of the final filter is a matter of balancing cost against operating advantages. The costlier washer-type element is practically damage- and rupture-proof and can be easily cleaned and re-used. The coalescer and final filter elements are combined into a compact in-line assembly. However, they also can be mounted separately when size limitations require this. Any number of elements and arrays can be mounted in the filter case to provide flow rates from a few to several thousand gpm.

To be used on the ground and in the air

Filter-water separators should be used wherever fuel is moved—at tank farms, in refueler trucks and trailers in filter meter hose carts, and in hydrant pits.

The moment the fuel leaves the last filter-water separator unit, another contamination process begins. Valves, meters, servo joints, and filler hoses add metal and rubber particles. Unless the fuel is pumped into the aircraft at low temperatures, much of the dissolved water will drop out either as free or as emulsified water as the aircraft gains altitude. If the fuel is not heated in the aircraft, this water will freeze.

A small filter-separator in each tank of the aircraft will get rid of this hazard. This unit also can be installed in the flow system of the fuel transfer pump. Fuel is continuously circulated through it and returned to the fuel tank. At each flight checkout, the filter-separator can be drained.

Continuous efficient operation of jet fuel filter-water separators is a critical requirement. If the elements aren't replaced or cleaned when they become loaded with contaminant, they eventually can fail because of excessive pressure differentials and let through small amounts of solid contaminants and water.

The pressure drop across a filter element indicates the operating condition. A new, clean element will start operating with a drop of about two psi. This differential will increase as the element collects contaminant. At a differential of 15-25 psi, the element should be replaced or, if possible, thoroughly cleaned. Otherwise the pressure differentials will rise quickly and may rupture the element.

If water is in the fuel passing through the filter, the pressure differential about doubles. Through differential pressure measurements —it is therefore possible to provide visual or automatic gaging and control means to shut off the fuel flow through a unit that isn't operating correctly.

In a new, purely automatic cutoff design, a filter with a fine-particle rating is placed in series with the exit flow from the separator unit. Any buildup of particles at this point will eventually clog the filter and shut off the flow immediately, should particles above a certain micron size pass through the filter-water separator unit.

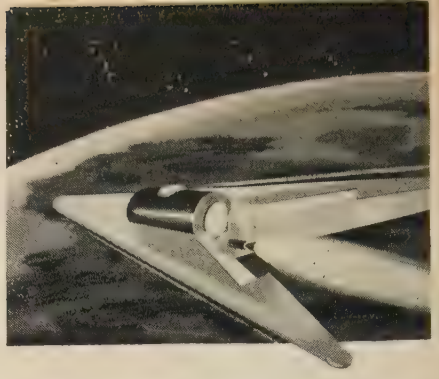
Such positive cutoff filters contain stacked-washer, resin-impregnated cellulose elements. Rated filtration is two microns. The elements are similar to the two-micron filters used for hydraulic fluids on missile test stands (*Fig. 2*). The rupture pressure of the cutoff elements is more than 6000 psi—well beyond fuel pump capacity.

These damage-proof elements can be quickly and easily cleaned. How many of them are needed depends on the flow rate. They can be installed on existing filter-water separators.

Automatic cutoff can also be provided by washer-type elements with fine-particle ratings that are installed in the second system of filter-water separators themselves. This design avoids the need for an outside cutoff filter. Write in No. 69 on Reader Service Card for more information.—End

A Correction

A superfluous engine somehow got into the Data Preview item "Light Jet", describing the Folland Gnat, on *page 250* of the July 1950 issue. The Gnat is powered by *a single* Bristol-Siddeley Orpheus 100 (rated at 4230 lb thrust), not by two Orpheuses, as was mistakenly stated.



ENGINEERS JOIN US...

for important work on recently assigned advanced research programs

Lockheed/California Division has recently been assigned vehicle projects with far-reaching military and commercial value. The advanced research and development work being conducted will have particular significance to the missile-spacecraft field.

An ideal research environment and advanced equipment provide the engineer and scientist with the utmost in freedom, recognition and advancement opportunity.

Generous travel and moving allowances to the San Fernando Valley will be provided for accepted applicants.

For your convenience in requesting an application form, tear out the coupon below and mail it today. For more details, see opposite page.

LOCKHEED

CALIFORNIA DIVISION
BURBANK, CALIFORNIA

Mr. E. W. Des Lauriers, Manager,
Professional Placement Staff
Dept. 1909
2400 North Hollywood Way
Burbank, California.

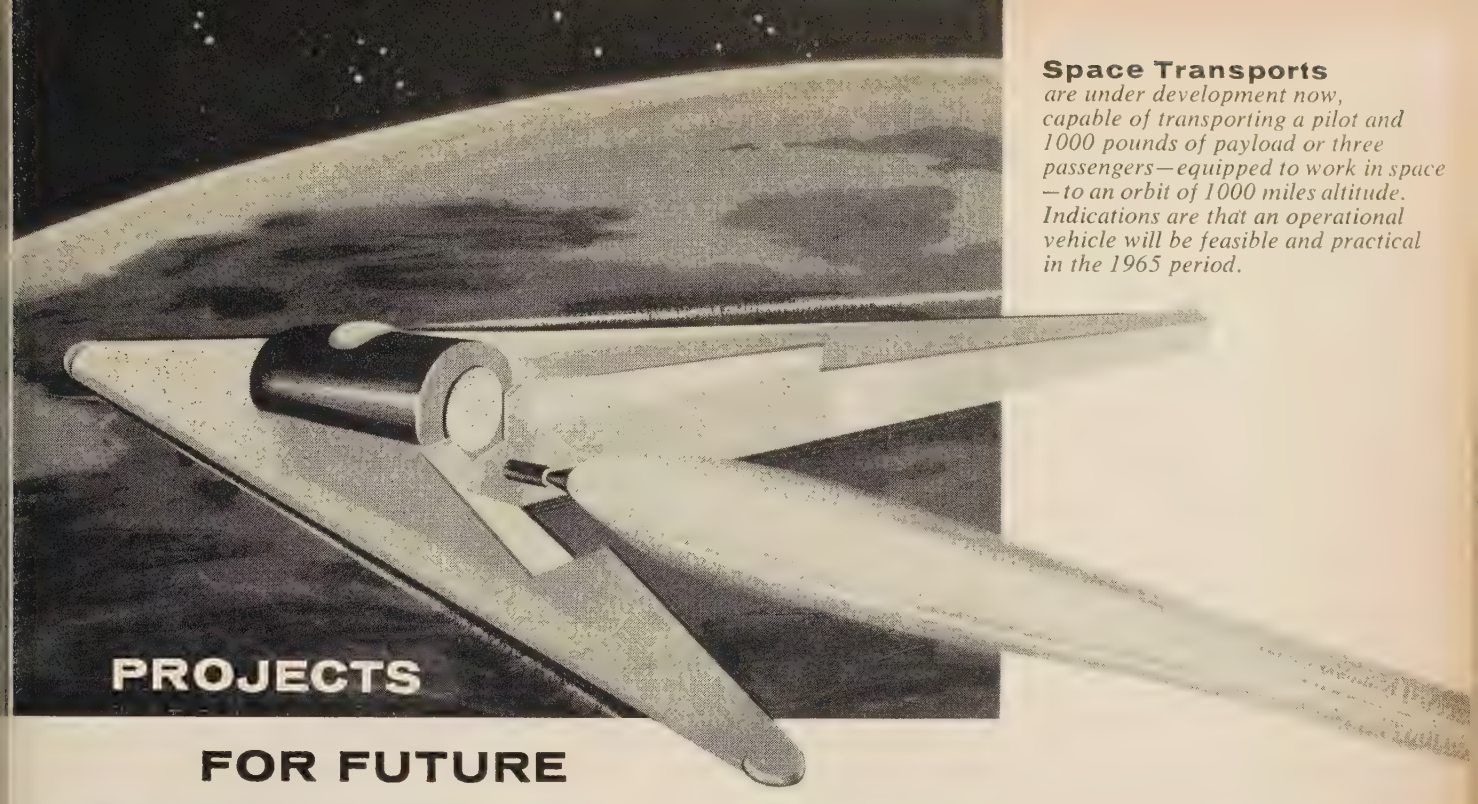
NAME

STREET ADDRESS

CITY & STATE

MY FIELD OF INTEREST

PHONE NO. DEGREE



Space Transports
are under development now, capable of transporting a pilot and 1000 pounds of payload or three passengers—equipped to work in space—to an orbit of 1000 miles altitude. Indications are that an operational vehicle will be feasible and practical in the 1965 period.

FOR FUTURE DECADES IN SPACE... *another Lockheed Progress Report to Engineers*

plotting the nation's future space exploration projects requires the capabilities of a forward-looking company; ne with vision, superiority in technical skills and advanced cilities. Lockheed, Burbank, long a leader in extending ne science of flight, is placing its vast resources and accu-mulated knowledge into programs designed to provide major breakthroughs in the fields of: Basic and applied esearch; manned aircraft of advanced design; missiles and pacecraft. Shown here are artists' renderings of a few of hese important projects. Such project diversification calls or high-level technical skill, offers genuine challenge to xperienced engineers. At Lockheed these varied projects equire engineers in many fields. Take advantage of this eed. Go forward with a forward-looking company: ockheed, Burbank.

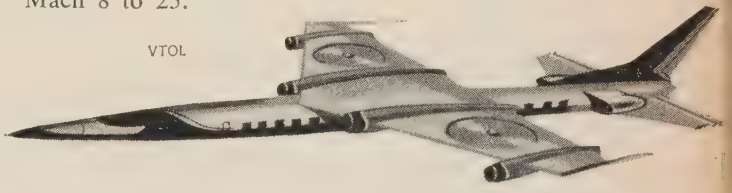
SUPERSONIC TRANSPORT

upersonic Transports—have held an important place n our thinking for the past several years. Extensive wind tunnel sts have been conducted on many design concepts, supplemented y exhaustive laboratory and structure studies. Lockheed is pre-ared to build an airliner that will travel at speeds in excess of Mach 3 at an altitude of 75,000 feet.

Infrared Systems studies are being conducted using an advanced method of detecting fast-moving missiles and high-speed aircraft.

High Altitude Flight Vehicle programs have recently been awarded to Lockheed for supersonic vehicles of improved aerodynamic design configurations with speed ranges between Mach 8 to 25.

VTOL



Vertical Take-off and Landing Projects—Lockheed, Burbank, is engaged in exploring the potential of VTOL projects on a very broad scale. Different VTOL features are embodied in each proposal. Considerable emphasis is being placed on VTOL "air recovery" vehicles, designed for air rescue and reentry missiles recovery missions.

Solar Radiation Studies—are being conducted at Lockheed's flight test radio station at Briar Summit, California, placing particular emphasis on solar flares.

Manned Vehicle studies are being conducted concerning fundamental problems associated with landing manned vehicles capable of hypersonic glide or orbit above the earth.

High caliber scientists and engineers are invited to take advantage of Lockheed's outstanding career opportunities. Openings now exist in: *Aero-Thermodynamics; propulsion; armament electronics—research and systems; instrumentation—wind tunnel servomechanisms—flight controls; dynamic analysis methods operations research; electrical instrumentation; physics; antenna underwater sound propagation; and manufacturing research.* Write today to: Mr. E. W. Des Lauriers, Manager Professional Placemen Staff, Dept. 1909, 2400 North Hollywood Way, Burbank, Calif.

LOCKHEED / CALIFORNIA DIVISION • BURBANK, CALIFORNIA

Check Employment Inquiry Form on Page 183

OUTPERFORMING all operational target missiles, Ryan's *transonic* Firebee has just set new world's records for altitude and duration-at-altitude.

...it flies *higher*—59,000 feet

...it flies *longer*—96.8 minutes *(77½ minutes above 50,000 feet!)*

...it flies *faster*—Mach .95

Now being produced for the Air Force (Q-2C version), Ryan's new *transonic* Firebee contains advanced, built-in auxiliary devices to better simulate enemy aircraft. It has the performance needed to challenge America's most advanced weapon systems under realistic combat conditions.

The *transonic* Firebee is the result of Ryan's unmatched ten years of design and operational experience in the jet target field.

In 1949, Ryan built the first jet target missile ... today more Firebees are in service—with the Air Force, Navy, Army, and Royal Canadian Air Force—than all other jet targets *combined*... and now, with this new *transonic* Firebee, Ryan gives proof again of its continued leadership in the design and development of jet targets.

RYAN OFFERS CHALLENGING OPPORTUNITIES TO ENGINEERS

RYAN BUILDS BETTER

AIRCRAFT • POWER PLANTS • ELECTRONICS

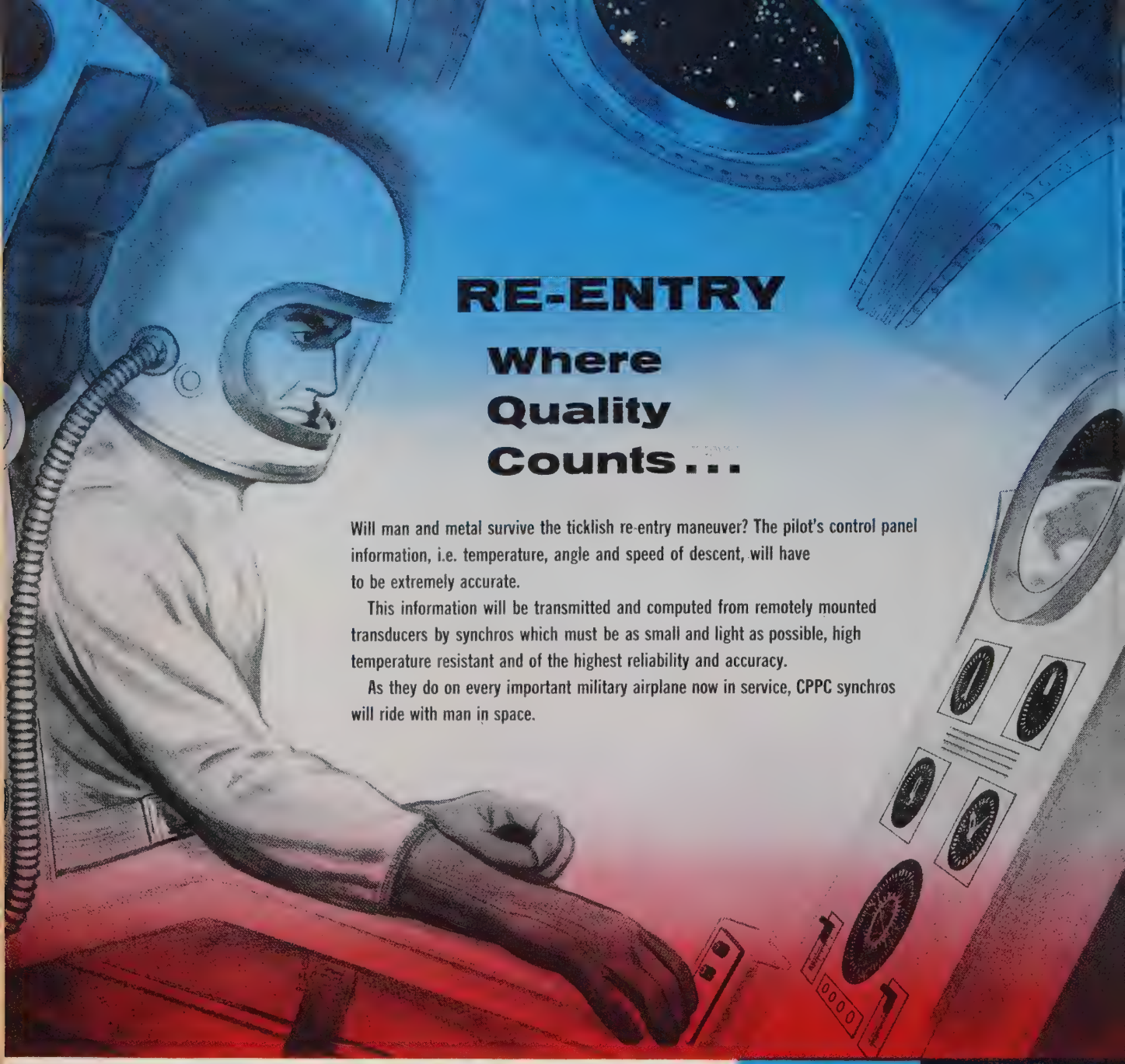
Ryan Aeronautical Company, San Diego, Calif.

Write in No. 116 on Reader Service Card at start of Product Preview Section

space/aero Electronics

DENDRITIC GROWTH

Molecular engineering research may have found a fully automatic method for mass-producing semiconductor devices in the form of dots deposited on germanium strips.



RE-ENTRY

Where Quality Counts...

Will man and metal survive the ticklish re-entry maneuver? The pilot's control panel information, i.e. temperature, angle and speed of descent, will have to be extremely accurate.

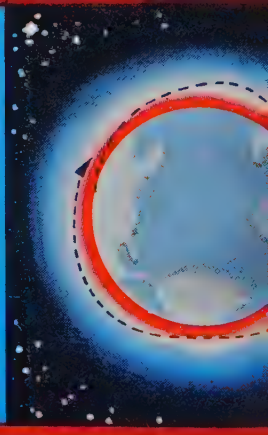
This information will be transmitted and computed from remotely mounted transducers by synchros which must be as small and light as possible, high temperature resistant and of the highest reliability and accuracy.

As they do on every important military airplane now in service, CPPC synchros will ride with man in space.

		PRIMARY						D. C. RESISTANCE		IMPEDANCE				ACCURACY
SYNCHRO FUNCTION	CPPC TYPE	Input Voltage (400 ~)	Input Current (Amps.)	Input Power (Watts)	Output Voltage (Volts)	Sensitivity (MV/deg.)	Phase Shift (deg. lead)	Rotor (Ohms)	Stator (Ohms)	Zro (Ohms)	Zso (Ohms)	Zrss (Ohms)	Max. Null Voltage (MV)	Max. Error (Min.)
Torque Transmitter	CGC-8-A-7	26	100	.54	11.8	206	8.5	37	12	54+j260	12+j45	80+j20	30	7
Control Transformer	CTC-8-A-1	11.8	.087	.21	23.5	411	9	143	24	210+j690	28+j114	250+j73	30	7
Control Transformer	CTC-8-A-4	11.8	.030	.073	22.5	393	8.5	365	64	470+j1770	81+j330	590+j190	30	7
Torque Receiver	CRC-8-A-1	26	.100	.54	11.8	206	8.5	37	12	54+j260	12+j45	80+j20	—	30 sp.
Electrical Resolver	CSC-8-A-1	26	.038	.39	10.8	183	20	230	27	270+j630	39+j142	340+j67	30	7
Electrical Resolver	CSC-8-A-4	26	.038	.39	26	454	20	230	170	270+j630	250+j830	340+j67	30	7
Torque Differential	CDC-8-A-1	11.8	.087	.21	11.5	204	9	36	24	38+j122	28+j114	47+j13	30	7
Vector Resolver	CVC-8-A-1	26	.100	.54	11.8	206	8.5	37	16.5	54+j260	19+j60	80+j20	30	7

See current catalogue for additional size 8 units

SIZE 8 SYNCHROS



CLIFTON PRECISION PRODUCTS CO., INC. cppc **Clifton Heights, Pa**

ENGINEERS – Challenging positions at CPPC in advanced Rotary Components and Computers. Write David D. Brown, Director of Personnel,

space/aero electronics intelligence

SPACE TRACK (System 496L) is the latest project at ARDC's Electronic Support System Project Office (ESSPO) at Wright-Patterson AFB, Ohio. It is essentially an expansion of the original USAF 1770 project at the Cambridge (Mass.) Research Center.

System 496L will be both long and short range. Under the project, USAF will update its present capabilities to predict and keep records of satellite orbits. Modernization of computation and communication capabilities and expansion of existing operations both at Cambridge and at spots all over the world are also included. Finally, the project will affect the plans for an advanced space surveillance system, to be developed in cooperation with ARPA.

HERE IS the lineup of other ESSPO projects: Air Weapons Control System (212L), Continental Aircraft Control and Warning (216L), Ballistic Early Warning System (224A), NORAD Combat Operations Center (225L), Weather Observing and Forecasting System (433L), USAF Intelligence Data Handling System (438L), SAC Control System (465L), Electromagnetic Intelligence System (466L), "Quick Globe System" (USAF Control System, 473L), USAF Communications Support System (480L), Air Traffic Control and Navigation System (431L).

Antenna arrays of British radio DF are electronically commutated

COMMUTATED antenna radio direction finder developed by Standard Telephones & Cables of London, England is the latest addition in one of the oldest areas of the radio art. The new DF comes in four models covering the HF, VHF, and UHF aeronautical bands. Antenna arrays of 12, 18, or 24 elements are electronically commutated to a dual-diversity, double-superheterodyne receiving system.

Bearing information, says the ITT subsidiary, is obtained by comparing signals derived from a phase detector with two orthogonal, fixed reference waveforms. The comparison is made in a novel electronic multiplier circuit. The device can detect the bearings of transmissions of only 50 milliseconds' duration.

Information is displayed on a cathode ray tube. Two independent bearings can be simultaneously presented on the same CRT—one as a solid trace, the other dotted.

<Write in No. 117 on Reader Service Card

FLIGHT CONTROL systems in the USAF inventory will be examined for their capabilities in automatic landing under an ARDC study program. Auto-throttle control will also be studied.

Current thinking is that the flight control systems now in use are not good enough for landing control. All were designed with the mission of the aircraft in mind—and this mission did not include landing control.

IN ANOTHER auto-landing study, WADC's Flight Control will try to find the best approach glide angles for USAF jets. The test aircraft will carry the radar seeker from a Sparrow II missile in its nose for precise detection of approach angles.

Good test results with PAR transponder beacon

TRANSPONDER BEACON designed by Stewart Warner to work with precision approach radar (PAR) has shown excellent results in tests, according to ARDC ESSPO's Air-Ground Subsystems Group. The system consists of airborne and ground units. X-band transmission from the PAR triggers and L-band reply from the aircraft, and the reply triggers the ground unit to send an X-band signal to the PAR. Compensating delays are built into the loop.

AGC circuitry holds the interrogation level to about the three-decibel (half-power) point. This point becomes very small at touchdown, so that the radar target shrinks in size as it approaches the runway. This effect gives much better definition than is possible with PAR skin tracking or conventional radar reinforcement beacons.

Tests show that, with a beacon antenna 5-7 ft above the runway, the PAR-Stewart Warner

more on next page

Cover story—Semiconductor device produced on germanium strip grown at Westinghouse is inserted in container. Dendritic action forms strip 1/8 in. wide and 0.005 in. thick. Devices are deposited as dots along strip and cut out for mounting.

beacon combination can distinguish between aircraft and runway on the radar indicator.

NEW PACKAGING technique devised by Stanford Research Institute uses two sets of eight transistor circuit elements mounted back to back in an aluminum window frame hinged at one end. All connections are made via a single 20-pin plug-in terminal. Its technique, says SRI, gives higher component densities than conventional methods, good vibration tolerance, and accessibility for maintenance and also lends itself to automatic manufacture.

Army to get an all-digital communications and switching system

DIGICOM, an all-digital communications and switching system designed by ITT Labs for the Army Signal Corps' R&D Lab, represents one of the giant steps military is taking to modernize a communications network that has lagged behind other developments of the aerospace age. The system will automatically bypass battle-damaged lines and reroute messages over the fastest available path. It will handle information from digital and analog computers, radars, teleprinters, tape readers, and voice and telemetering systems.

With Digicom, says ITT, telephone messages are virtually immune to interference. The system transmits speech by an ITT's patented "delta pulse code modulation" method.

UNDER DIGICOM'S time sharing concept, the number of wire pairs needed for 24 phases is cut from 48 to two. The number of cross-points needed to carry on 48 simultaneous conversations is cut from nearly 10,000 to less than 500. Each Digicom unit handles four local loops with up to 24 phones. The system is completely transistorized and dissipates less than 30W.

Digicom, says ITT, may be worked into the Army's new tactical plan for laying battlefield communications throughout a combat area.

MICROWAVE-POWERED sky station, proposed by Raytheon, will be looked into under a DOD study contract. The idea is to beam megawatt microwave energy from a converging beam antenna array to antennas on a hovering communications and detection station. Source of the energy would be Raytheon's amplitron microwave amplifier.

At the station, the microwave energy would be converted into heat and furnish power for the station's rotary wings and electronic equipment. Details of Raytheon's proposal are classified.

CUTLER-HAMMER'S Airborne Instruments Div. got a $232,310 WADC contract for developing and making a "molecular amplifier group." The group is to be used as a low-noise front end for an existing telemetry system operating in the 2150-2350-mc band. WADC's design objectives call for a minimum gain of 20 db, a maximum bandwidth of four mc, a noise factor of less than 0.5 db (at a maximum effective input noise temperature of 35 deg K), and rapid tuning over the entire bandwidth.

RECENT ACQUISITION of Wheeler Labs by Hazeltine now gives this highly-rated electronics company facilities in Burbank, Calif., Chicago, Indianapolis, Ind., and on Long Island. The latest building project is a 50,000-sq ft engineering lab featuring an advanced sonar test tank. With Wheeler Labs (specializing in microwave design and antennas) in the family, Hazeltine is in a better position to bid for weapon system prime contracts, especially those involving complex ground and airborne guidance and tracking systems.

LOCKHEED awarded an initial subcontract worth over $2 million to Packard-Bell for elements of the automatic checkout systems for the Navy's Polaris. These are probably the adapter units needed to let flight testing to proceed. Later there'll be an industry scramble for the main programer controller system.

Statistical telemetering to be used on Mercury

APPLIED SCIENCE Corp. of Princeton, N. J., has a contract worth about $100,000 from McDonnell for airborne statistical telemetering equipment to be included in the Mercury payload. This marks the first practical use of the statistical technique, long pushed by ASCOP.

The package is a solid-state, dual-channel airborne spectrum analyser for vibration and acoustic data. ASCOP says the device may make it possible to cut bandwidth requirements from several kilocycles to near zero—which would save transmitter power, lead to simpler equip-

more on page 148

Some Ideas

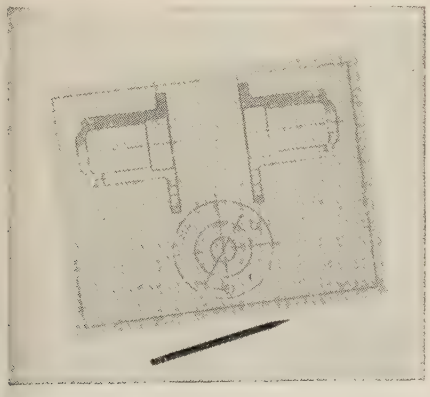
for your file of practical information on drafting and reproduction from

KEUFFEL & ESSER CO.

A year of relentless testing has produced a small library of interesting facts about HERCULENE (T.M.) Drafting Film. What follows is a consensus of drafting-room experience with HERCULENE—by K&E and its customers—with some up-to-date recommendations for using it. Take the matter of . . .

Shiny Back vs. Pencil Back

A basic question is: do you need a double-surfaced drafting film? We make HERCULENE Drafting Film both ways, of course —with a single surface (shiny back) and double surface (pencil back). It's our recommendation that you use pencil back HERCULENE only if it's your practice to make basic drawings on one side, changes on the other. For most other uses, shiny back is preferable. (At first, the double-surface film was chosen by many drafting rooms because it lay flatter on the board than shiny back. This is no longer true. K&E research labs have come up with a fully effective anti-curl treatment.) Especially in filing, shiny back HERCULENE presents fewer problems. The clean non-abrasive back won't smudge the face of the sheet underneath, even in a heavy stack of tracings. If you'd like to compare a few sheets, please let us know.



Note sharp clear lines made by Duralar pencil on HERCULENE Drafting Film.

Plastic Pencils and the HERCULENE Surface

Not just a handy catch-phrase, when K&E puts its exclusive "engineered surface" on a drafting material, the result is an exact, uniform tooth for sharp pencil drawing, inking and typing. With HERCULENE Drafting Film, however, an entirely new type of plastic (non-graphite) pencil yields especially good results. Quite a few of our customers have reported favorably on the well-known Staedtler "Duralar" brand. Duralar pencils come in five hardnesses, are non-smudging and have generally good covering power, sharpness and erasability. After about 20 prints, the Duralar lines show up consistently better than those made by a regular pencil, since graphite lines tend to lose density.

Wet That Eraser!

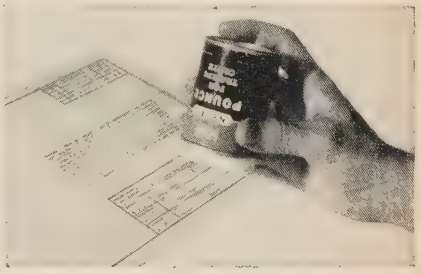
The erasing qualities of HERCULENE Drafting Film are excellent, but (as with the pencils) we've discovered it's a new type of vinyl eraser that gives the best results. Examples of these non-rubber type erasers are the Richard Best "TAD" and the Eberhard Faber "RACE KLEEN" — both available from your K&E dealer. With vinyl erasers, pencil lines whisk off. Even stubborn ink and typing can be removed easily, with no damage to the surface. Here's a tip on how to do this:

Moisten the eraser slightly. It becomes no more abrasive, but a lot more "erasive." Moistening is a must when removing Duralar lines or typing after exposure to heat. (Incidentally, don't use electric erasing machines, steel erasers or typewriter erasers.) When erasing large areas, certain chemical eradicators work fine too. Our suggestion: use Vythene or a very light application of a denatured alcohol such as Solox, both of which can be applied with a cotton swab or clean cloth.

The Cleaner the Better

HERCULENE Drafting Film was designed for ink work, and its ink take is unexcelled. But like all films, its non-absorbency makes a few preparations advisable. The surface should be cleaned thoroughly before inking. Quickest and most effective way to do this is with the ABC Draftsman's Dry-Clean pad, which will remove finger marks and "traffic film" simply by rubbing the pad over the surface. Pouncing will also work well. A damp cloth is all right for general cleaning, but does not do the best job of preparing the surface for ink.

Inking over graphite pencil lines comes out best when done over light lines, drawn with a harder grade of pencil. A good way to remove excess graphite is to go over the drawing with an ABC pad. Inks vary in their usefulness on HERCULENE. We've tested several, and you're welcome to these results as well, on request.



After Typing, Please Pounce

Typed impressions on HERCULENE Drafting Film are crisp and sharp, but may take a while to dry because the film's surface doesn't "swallow" ink readily. A light pouncing right after typing will dry the ink and fix the lines — giving you uniform permanent contrast.

A new typewriter ribbon will produce the best impressions. At K&E we've tested a healthy variety of ribbons and we'd be pleased to send you the results on request.

Outstanding Advantages Proved in Tests

We're pleasantly amazed at the short time it took for HERCULENE Drafting Film to become an accepted "staple" — along with ALBANENE® Tracing Paper and PHOENIX® Tracing Cloth. Actually, it's a rare drafting room by now that has *not* tested HERCULENE during its first year on the market. The findings: All properties considered, HERCULENE stands up better than any other drafting film. It has great resistance to heat, aging and abuse. Its exclusive "engineered surface" plus its tough, durable Mylar® base provide superior pencil and ink take, fine erasability, remarkable dimensional stability...a combination we're proud to call unbeatable!

The K&E dealer near you has HERCULENE now. Stop in and see him.

KEUFFEL & ESSER CO., Dept. AA-9, Hoboken, N. J.

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ment, etc. Each channel of the statistical device produces a complete spectrum in several seconds.

NASA PICKED Western Electric's Defense Projects Div. to build a world-wide network of tracking and ground instrumentation stations for Mercury. Major electronic contractors to W-E are: Bell Labs for system engineering, engineering consultation, and command and control displays; IBM for computer programing, simulator displays, and computers; and Bendix Aviation for radar installations, ground-to-air communications, telemetry, and site display equipment.

HIGH POWER silicon transistor developed by Westinghouse's Semiconductor Dept. reportedly can control over five kw of power when used as a switch. Still in the prototype stage, these transistors will be the highest-powered devices available in either germanium or silicon, says D. W. Gunther, manager of the department. They have collector-to-emitter voltage ratings of 30-200 V, a maximum junction temperature of 150 deg C, and less than 0.1 ohm saturation resistance. Production of the units isn't too far off.

15-in-1 microminiaturized flip-flop circuit

MELPAR reports that a special research program it started for the government last September has paid off in the successful production of a 15-in-1 microminiature version of a standard computer part, a binary flip-flop circuit. So small it's hidden under a five-cent coin, the circuit mounts all of its tiny components — transistors, capacitors, diodes, and resistors — on a ceramic base 0.625 in. square and 0.020 in. thick. Reliability is better than the bigger version it replaces, claims Melpar.

MINNEAPOLIS-HONEYWELL received a $5.4 million contract to develop and produce inertial guidance systems for Centaur, our first high energy space vehicle. Contract was awarded by Convair-Astronautics, prime contractor for the vehicle. Centaur's missions include dropping a half-ton payload on the moon and placing space research and communications satellites in precise orbits ranging from 300 to 20,000 miles.

IG equipment will be a pure inertial version of M-H's MIG (*M*iniature *I*ntegrating *G*yro) system (see *S/A, "Design Digest: MIG Platform Extends Inertial System Use," July '59, p. 128*).

GOODYEAR'S Aviation Products Div. developed a seamless, inflatable radome for the missile-tracking antennas of the Nike-Zeus system that reportedly scores breakthrough in radar cover design. According to Ed Wolf, manager of the division's Special Products Dept., the radome is made in "orange peel" sections, staggered and laminated to give a cover of uniform $\frac{3}{32}$-in. thickness. The result is electronic invisibility with better radar operation at both high and low frequencies, Wolf claims.

The coated nylon radome contains 25 per cent less fabric than do conventional types. It's built to withstand 150-mps winds and temperatures from —65 to 135 deg F. Five men can set up the 54,000-cu ft dome in about two hours, Wolf says.

RESEARCH in undersea warfare techniques and hardware has increased sharply over the past decade—from about $7.5 million reported for '47 to $35 million in '54 and about $150 million today, according to one industry source.

Limited sound sources in audio range troubling sonar researchers

WHILE BASIC researchers are concentrating on unconventional undersea detection techniques, sonar—virtually dormant for many years—is also picking up speed. Improvements in existing hardware rather than new techniques are the major goal. Interviews by SPACE/AERONAUTICS, hydroacoustics engineers explained that the fundamental acoustic design formula for sonar is the same as that for transducers in air (aside from incidental problems of waterproofing, corrosion, and static pressure). One of the big problems in perfecting underwater sound transducers is the limitations of the sound sources in the audio range. To calibrate standard transducers, the Navy is looking for a broadband, high fidelity underwater sound source that can produce a constant sound field over wide frequency ranges.

STROMBERG-CARLSON'S Hydro-Acoustics Research Lab, which now has a sonar test tank facility, is working on an underwater sparking device that may be just what Navy is looking for. Arcing is produced in a submerged electrode. To date, S-C has succeeded in attaining the sound equivalent of an explosive cap discharge with greatly improved directivity and fidelity.

THE NAVY'S POLARIS:

DONNER *helps it think...*

One day soon the U. S. Navy will file a report more fantastic than any sea serpent tale we've ever heard. This will be the launching of the Navy's spectacular Polaris missile from a submerged nuclear submarine. Advanced testing is underway; the Polaris will be ready for the fleet in 1960.

Smaller and lighter than other intermediate range ballistic missiles, this formidable Lockheed developed weapon features much that is new in advanced electronics. It even "thinks" for itself.

One such "think" device aboard the Polaris is a system developed by Donner Scientific Company using as a base a standard Model 4310 Accelerometer. The system monitors flight performance like a policeman directing traffic. If, for example, in the initial portion of the flight, the missile does not achieve sufficient velocity by a pre-determined time, the Donner system aborts the flight. The missile gets the go-ahead only as programmed.

Donner's role in the Polaris project represents another basic contribution from an engineering team which specializes in accurate systems, interlocking time, acceleration, velocity and other inputs designed to meet customers' requirements.

Donner welcomes your inquiries concerning the company's capabilities in this and related fields.

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FIGURE 1: Required vs available power (left) for typical Century series fighter at various loads, airspeeds, and angles of attack (dashed lines). Margin of power available for acceleration is shown by vertical distance between curve for required power (in level flight) and military-power line. It decreases with increases in gross weight and/or attack angle. Flight to the left of B-B′ ′ ′ is known as being on the "back side of the curve." Most high speed jets make their landing approaches slightly to the left of B-B′ ′ ′. Flight to the left of C-C′ ′ ′ can be dangerous because of rise of required power. Right: ILAS-flare profile. Angle between glide slope and runway is 2½-6 deg. Improved localizer and accurate heading reference are used for lateral control from 200 ft to touchdown.

Operational needs speed up

automatic landing progress

We've got the electronics to hit a pickle barrel at 5000 miles with an ICBM, guidance experts brag. What we don't have, badly as we need it, is the electronics to land an airplane when the pilot can't see the runway. This special S/A survey reports on our progress toward a truly workable blind landing system for routine military and civil flights.

by James Holahan, Electronics Editor*

AUTOMATIC LANDINGS are now regarded by the U.S. military as a definite necessity for future aircraft operations. The European airlines recently came to the same conclusion. Our own airlines so far haven't bought the concept as a whole. But they are slowly coming to admit that—for safety as well as just plain economics—the airliner of the future must be able to make blind landings.

Blind landings do not necessarily have to be automatic too. So long as the proper guidance and display are supplied, an aircraft could be landed blind manually. However, tight control and quick reactions are needed, and the margin of error is slim, especially at high approach speeds. It appears therefore that blind landings might as well be mechanized from the start—perhaps

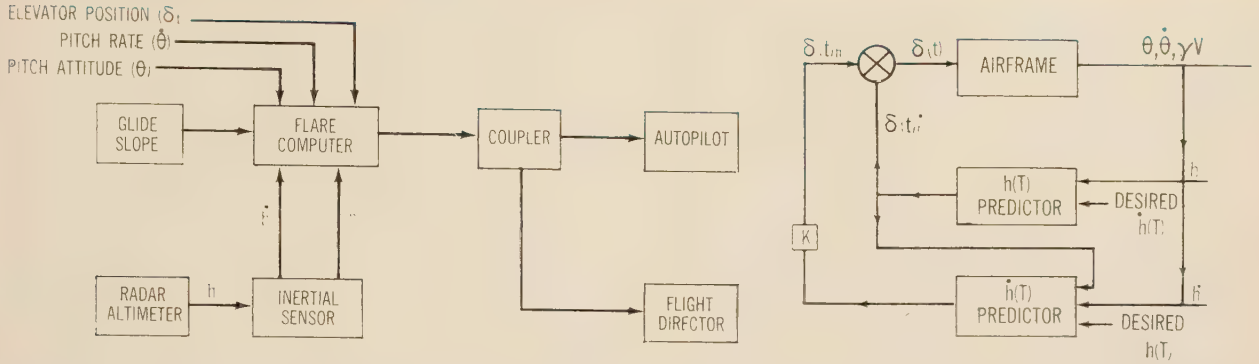

FIGURE 2: Jetliner landing system (left) foreseen by Autonetics. It uses "state-of-the-art hardware." Altitude is sensed by the radar altimeter; the sink rate is derived through the inertial sensor. The system needs narrow-beam localizer and glidepath like MRN7 and -8. Right: Flare computer designed by Autonetics (left). Based on terminal-control design principles, a computer of this type will be a part of Autonetics' APN-114 flare-type landing system, to be tested soon by FAA. The system has three guidance modes, the first of which will use ILAS. Altitude will be measured by a combination of barometric and radar altimeters. The most sophisticated design feature of the system is the computing servo, which Autonetics calls a "two-condition terminal controller."

	Phase	Altitude (ft)	Control	
			Azimuth	Elevation
1-2	Automatic Approach Track		ILS localizer, compass	barometric height
2-3	Glide	to 300	ILS localizer	ILS glide path
3-4	Automatic Landing Leader Cable	300-150	leader cable	ILS glide path
4-5	Attitude	150-60	leader cable	fixed attitude
5-6	Flare	60-20	leader cable	radio altimeter
6-7	De-Crab	20-0	compass	radio altimeter
7-8	Manual Ground Run	0	leader cable compass	

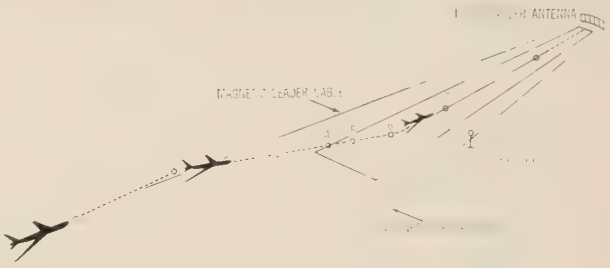

FIGURE 3: BLEU landing system uses improved ILAS, magnetic leader cable, and radar altimeter. BEA, BOAC, and RAF will use this system or a derivative. The latest plans call for elimination of the leader cable and the use of localizer and aircraft heading reference for lateral control in the final phases—provided the runway is wide enough (about 250 ft).

with the pilot serving as monitor and vernier controller.

Actually, why do we need automatic landing? There are two reasons. One is obvious: *all-weather operation.* The other is less obvious and relatively new: *safe, uniform operation of aircraft.* Because they are already operating a variety of latest-generation aircraft, this reason has become more important for the military services. As they switch to jets, the airlines, too, are paying serious attention to what automatic landing can buy in the way of flight safety.

High performance jets are built with the mission performance requirements as the unyielding factors in their design equations. To maximize cruise speed, endurance, payload, etc., the designer often is forced to compromise on low speed handling characteristics. Lift-drag ratios are low, wing loading and landing speed are high, and the angle of attack is critical. Look at the approach and landing speeds of some current jets: Convair F-102, 180 and 160-170 knots; Republic F-105, 190-200 and 170-180 knots; Boeing 707, 130 and 120 knots.

Another problem with the jets is their high fuel consumption at low altitudes. This can make a missed approach a serious situation.

Statistics show that landings account for most aircraft accidents. Civil Aeronautics Board statistics show that, from 1947 to 1958, 44 per cent of all air accidents involving civil transports occurred during landing. USAF has figures to show that landings account for some 43 per cent of its accidents.

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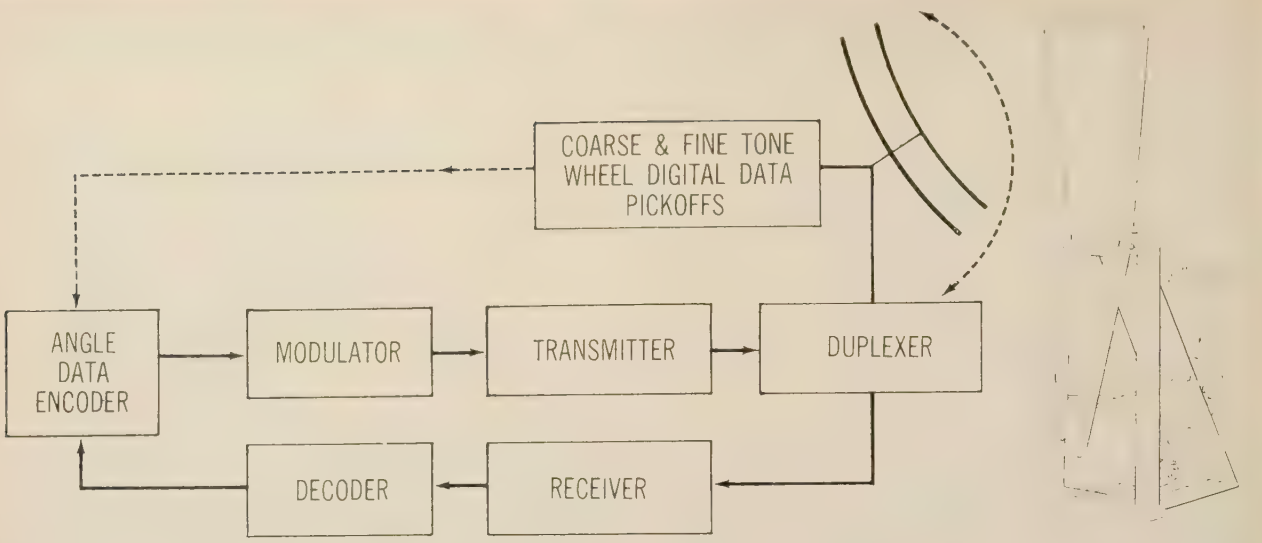
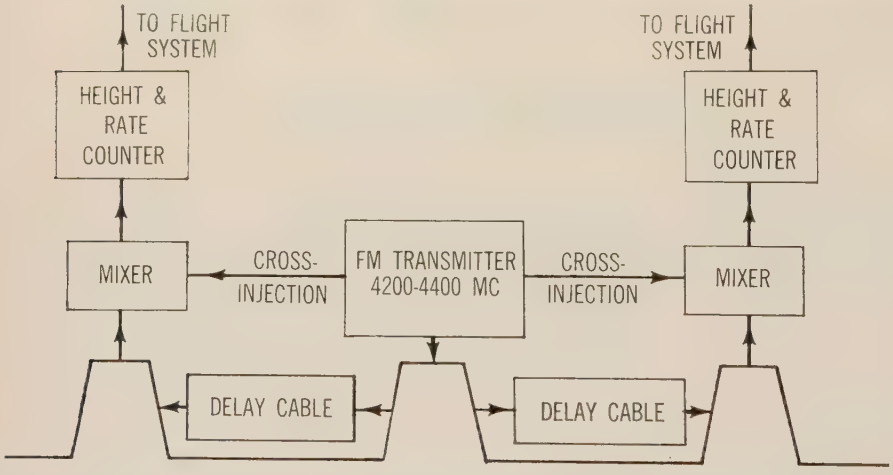


FIGURE 4: Regal's ground electronics will be located near the antenna to shorten the waveguide run. The receiver amplifies the aircraft's range interrogations and feeds them to the data encoder. Here the range replies are mixed with angle data for transmission back to the aircraft. The dual-array antenna radiates while scanning in the down direction only. Right: Regal antenna has two time-shared linear arrays which, driven by flywheel and motor, scan in the elevation plane but in opposite directions. While one array is nodding downward, the other is traveling upward. The arrays are energized only in the downward scan to prevent ground reflection errors. The radiated pattern is a 0.5-deg beam in the E-plane with a sharp null in the center. Scan rate is five per second.



RADAR ALTIMETER planned by Standard Telephones & Cables for automatic landing. Output would be linear up to 200 ft. At present, no radar altimeter is available that's good enough for automatic landings.

A particular landing hazard of military jets is that pilots slowing them down for landing can get into the awkward position of not having any thrust available to maintain level flight or retard the sink rate. This condition occurs when the aircraft is flown far on the backside of the power curve (*Fig. 1*).

Most approaches in high performance jets are made slightly on the back side of the curve. Throttle is reduced to kill off speed, and the nose is picked up to keep a steady rate of descent. As the nose comes up, induced drag increases, so that, although the plane is flying slower, the required power is greater. This power is absorbed just to balance out drag. If the pilot gets too far to the left on the curve, his only recourse is to lower the induced drag by lowering his angle of attack. But then he'll lose precision altitude—which he just doesn't have on final approach.

If the trend to higher landing speeds and less forgiving approach characteristics continues, greater pilot proficiency will be demanded not only for IFR approaches but for routine approaches as well. The most acceptable, and possibly the only solution in both military and commercial operations might very well be automatic or semi-automatic landing control.

R&D programs in automatic landing have been underway for a number of years at BuShips and BuAer (a

joint effort), Britain's Royal Aircraft Establishment, USAF Tracals Group (now part of ARDC's Detachment 1), and WADC's Flight Control Lab. Recently, the Federal Aviation Agency (FAA) started a three-phase program that looks like the most intensive effort to date:

- Phase I will concentrate on improving the localizer and glide slope parts of the instrument low approach system, continuing work started several years ago by the Civil Aeronautics Authority.
- Phase II will evaluate two systems developed for the military (Bell Aircraft's automatic landing system and Autonetics' flare computer) to find out if they can be used in the common system. FAA may also look into the possibilities of the system developed by the British RAE's Blind Landing Experimental Unit (BLEU). FAA is planning only on interim use for the Phase II systems.
- In Phase III, FAA will try to find out just what it needs for a landing system of the future. Two systems are to be studied: Gilfillan's Regal (*R*ange and *e*levation *g*uidance for *a*pproach and *l*anding) and Airborne Instruments Lab's "double-angle" design.

The *Table* lists the five automatic-landing concepts that, in the view of military and FAA experts interviewed by SPACE/AERONAUTICS, look most promising. In addition, there are two flare-out systems, which are being worked on by Minneapolis-Honeywell and Sperry Gyroscope, respectively, and bear watching. Cubic has proposed a version of its Moptar miss distance indicator for Nike, and has stirred up interest at FAA.

Only the BLEU and Bell systems can qualify *right now* for the full automatic landing job from approach to touchdown. Both are in the prototype stage, and both have been through over 2000 blind service test landings.

At this writing, it seems certain that RAF, BEA, and BOAC will install at least the flare computer part of the BLEU system in future aircraft. The Bell ALS has already passed its first Navy and USAF initial tests with flying colors, and operational test models are being built for both services. One of Bell's units will be installed on the aircraft carrier Enterprise next year.

Most thoroughly tested system

BLEU claims to have the most extensively tested automatic landing system. During development and service testing of various configurations, BLEU has made a total of some 3000 blind landings. About a third of these were fully automatic, the others semi-automatic. Two specially instrumented aircraft, a Canberra jet and a piston-engine Varsity (equivalent to our Douglas DC-3), were used.

The BLEU system uses ILAS, a radar altimeter, and magnetic leader cables as guidance elements in the sequence shown in *Figure 3*. The approach is divided into three modes, with radar-measured altitude supplying the trigger for the switches from mode to mode. (In operation, a ground beacon could be used as a backup signal to insure correct switching). According to the British designers, the transition between modes is so smooth that the landing becomes a single, integrated maneuver.

more on next page

Characteristics of Automatic Landing Systems

Developer	Blind Landing Experimental Unit, RAE	Bell Aircraft	Autonetics Div., North American Aviation	Gilfillan Bros.	Airborne Instrument Labs
Type	ILAS-flare computer	radar-computer	ILAS-flare computer	"scanning-beam DME"	"scanning-beam ILS"
Sensed Parameters	h, $\dot{h}$ (radar alt)	azimuth & elevation angles, slant range	h (barometric), $\dot{h}$ (radar alt), $\ddot{h}$ (integrating accel & radar alt)	elevation & azimuth angles, slant range	2 elevation angles
Lateral Guidance	ILAS localizer or magnetic leader cables	radar & computer	ILAS localizer	coded X-band scanning beam	not being considered yet
Vertical Guidance on Approach	ILAS glide slope	radar & computer	ILAS glide slope	coded X-band scanning beam	coded Ku-band scanning beams
Flare Guidance	computer—$\dot{h}$ made function of h; final rate inserted as open-loop bias	radar & computer	two-condition terminal , computer — h and $\dot{h}$ go to zero and 2 fps, resp., at touchdown	no flare provided as yet	coded scanning beam & computer—$\dot{h}$ and h go to zero with distance to touchdown
Type of Flare	exponential, fixed shape	exponential, fixed shape	circular arc, $\dot{h}$ held constant		modified parabolic
Dispersion Lateral Longitudinal Sink Rate at Touchdown	 12 ft RMS 480 ft RMS −0.8 fps RMS	 ±15 ft (USAF), ±10 ft (Navy) ±200 ft (USAF), ±20 ft (Navy) 2 ± −1 fps (USAF), 6-12 fps (Navy)	 limits of ILAS localizer ±150 ft (no wind) 2 ±1 fps	not tested yet as complete system	not tested yet as complete system
Status	service test; has made approx. 3000 blind landings	service test; has made over 2000 blind landings	active project at WADC; scheduled for FAA tests	elevation measuring part in prototype, scheduled for FAA tests	breadboard; model being built for FAA tests

At the start of mode 1, the aircraft is under localizer and glide slope control to a point roughly 300 ft up and 6000 ft from the runway threshold. Then lateral guidance is taken over by the leader cable system. The combination of glide slope and localizer guides the aircraft to about 150 ft, the lower reliability limit of many glide slope installations.

In mode 2, from about 150 to 60 ft, the aircraft is controlled on an open-loop scheme using a mean pitch attitude signal derived while the aircraft is on the glide slope during phase 1.

At about 60 ft, the final phase begins. The pitch control is commanded to apply a normal acceleration such that the aircraft describes an exponential, fixed-shape curve asymptotic to the runway. The command input is:

$$E_p = h + \tau \dot{h},$$

where E_p is the error generating the pitch command and τ the time constant. Assuming no error, we get:

$$h = ke^{-t/\tau},$$

where k is the height at the start of the flare, and t the elapsed time. Time constant τ is chosen so that the exponential curve is tangential to the glide slope at the start of the flare. A fixed bias is added to the command signal so that the aircraft seeks a virtual runway about a foot or two below the actual one and is kept from floating. As a descent rate and not a descent path is called for, the aircraft is not restricted in its path, only in the shape of its path.

BLEU controls airspeed also

Besides pitch, yaw, and roll control through the airplane's autopilot, the BLEU system controls airspeed by regulating the throttle. Airspeed is kept constant during the final approach, and the throttles are cut back to idle, as in a manual landing, just before touchdown. The British firmly believe that speed should be controlled during automatic landing (especially in jets), because of the large effect of engine thrust on the amount of runway used during flare.

The BLEU system commands a decrab maneuver at about 20 ft. At this point, the magnetic cable guidance is uncoupled and the aircraft is "skidded" (turned by the use of rudder only) to the runway heading.

In 125 Varsity landings with BLEU, the lateral dispersion (with leader cable) was less than 12 ft RMS; and the sink rate, 0.8 fps RMS.

The magnetic cable guidance used by BLEU was developed by Murphy Radio and is unique among the guidance designs used in landing schemes. It is based on magnetic fields surrounding the alternating currents that flow in two leader cables stretched parallel along the sides of the runway. The cables begin about halfway down the runway and extend some 6000 ft beyond the threshold. Murphy claims a maximum lateral error of 7½ ft to either side of the centerline.

For all its uniqueness, the magnetic-cable guidance is a sore point with potential buyers of BLEU. It requires more than a mile of real estate in front of the runway. That kind of land is hard or even impossible to get at most airports.

The radar altimeter used in BLEU is made by Standard Radio & Cables especially for the landing job. FAA recently ordered three of these units for evaluation.

Bell's automatic landing system uses a ground-based, K_a-band, conical-scan acquisition and tracking radar as well as a computer and data link (see *AvAge, "Bell Designs First Automatic All-Weather Landing System," Aug. '57, p. 104*). The aircraft needs only a corner reflector, or radar-reinforcing beacon, a data link receiver, and a switch to disable the normal autopilot coupler washout terms and circuits that vary sensitivity with range.

Bell has made over 2000 successful blind landings so far with a variety of commercial jet and piston planes, a carrier-based jet and other military aircraft, and a Regulus II missile. The SPN-10 version of Bell's system to date is the only system that has been able to land an aircraft blind on a carrier deck. About a year ago, SPN-10 made 35 successful touchdowns in a Douglas A3D.

The carrier system includes a deck motion prediction computer as well as the flight path computer used for normal landings. It has no flare-out provisions. Carrier aircraft are flown "into the deck" out of a three-degree glide with a sink rate between four and ten fps. As there is no flare, dispersions are quite narrow—longitudinally they amount to ±18 ft.

Bell is building a service test model for USAF and FAA. This GSN-5 version uses two radars to get a two-per-minute landing rate. While one radar is landing one aircraft, the second is bringing the next one in on final with a path separation of about two miles.

Dispersion of the GSN-5 is ±10 ft laterally and ±100 ft longitudinally. Sink rates are 1-3 fps.

The Bell system sets up a path in space that is a function of aircraft-to-touchdown range, aircraft speeds, headwind, and aircraft glide angle. Position is measured (relative to touchdown) in rectangular coordinates.

The pitch system is a closed-loop servo. The desired altitude for actual range (as measured by the radar) is compared with actual altitude. The computed error, error rate, and an integral term are combined to form a pitch command. The rate signal provides a damping factor, while the integral is used to wash out long-term trim and drift errors. Actual altitude is measured by taking the integral of vertical velocity, which is computed from the product of slant velocity and glide angle (also determined by radar).

In the lateral axis, the lateral displacement and its time derivative and an integral term combine to form a bank angle command in a manner analogous to that of the pitch channel. As aircraft position is computed in rectangular coordinates, the loop sensitivity is independent of the range from touchdown.

The range of the Bell system is four nm in 10 mm of range. Although the military apparently feel this is adequate, many of the civil operators believe this relatively short range could create a bottleneck in a dense air traffic control situation.

Flare follows a fixed path

For flare-out, Bell continues its closed-loop servo techniques to perform an exponential, fixed-path flare. Both height and sink rate are programed as functions of range to go. Closed-loop techniques are in pitch for the flare, with airframe lags compensated out automatically. Altitude and vertical velocity errors are corrected for during the flare by adhering to a fixed path in space. Although the system allows tight dispersions, gusts can cause abnormally high sink rates. However, according to Bell, altitude can be controlled within a foot in turbulence.

Autonetics' APN-114 flare computer was originally developed for the Navaho missile's test vehicle. Like

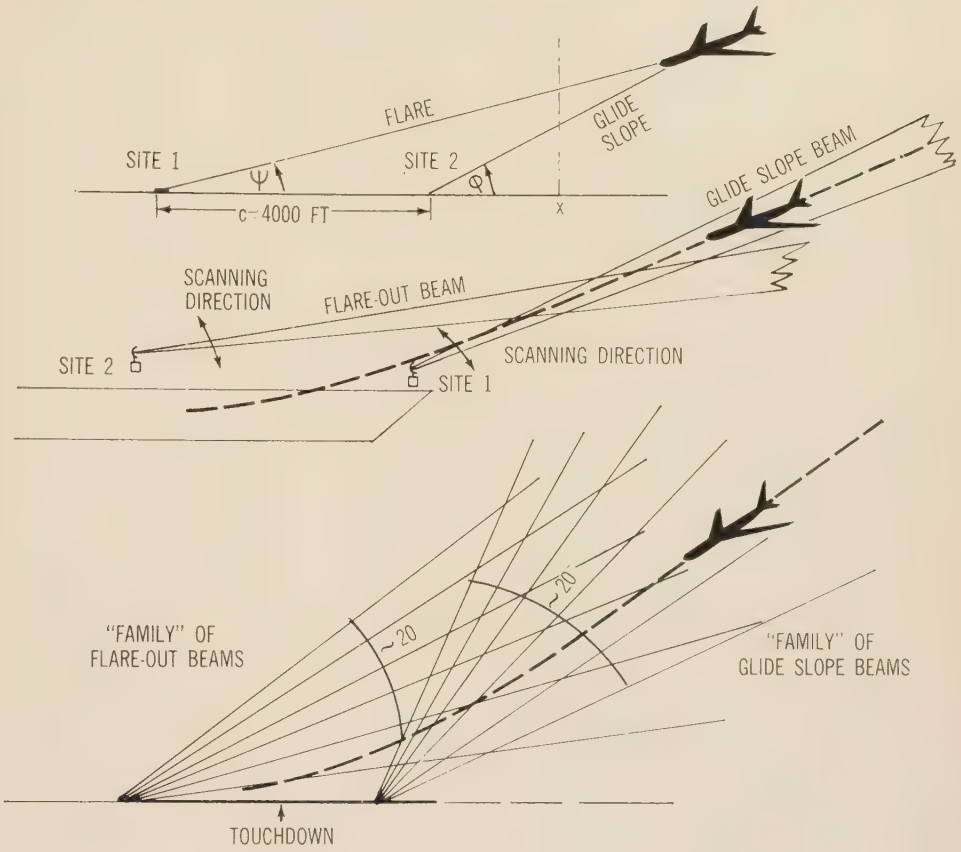


FIGURE 5: Angular position determination method was suggested to FAA by Airborne Instruments Lab. Two E-plane scanning beams are used. Any of a "family" of front beams is selected by the airborne equipment to establish the desired glide slope. (The aircraft holds the glide path by keeping $d\phi/dt$ to zero.) As the aircraft approaches a flare-out "family", a gradual transition is made to a selected beam, and the plane starts the flare. The distance to go can be calculated simply from the distance between the antennas and the angles ψ and ϕ.

other flare computer types, it needs lateral and vertical guidance up to the beginning of the flare and lateral guidance to the "decrab" point.

A complete landing system containing the APN-114 would have three guidance modes. According to Autonetics, guidance for the first phase is by ILAS. Altitude is measured by a combination of barometric and radar altimeters. (A special version of Emerson's APN-100 radar altimeter is used.)

During the first, or glide slope, mode, the time required for touchdown intercept is computed by dividing altitude by altitude rate. An integrating accelerometer measures rapid changes in the altitude rate. Its superior high frequency characteristics overcome the effects of terrain irregularities, noise, lag, and other factors that limit the rates derived from radar-measured altitude. The inertial instrument is calibrated by the barometric rate during mode 1 and by the radar rate during modes 2 and 3.

A computing servo is the most sophisticated design feature of Autonetics system. A "two-condition terminal controller," it continuously recomputes the autopilot commands that will make the airplane have zero altitude and a two-fps sink rate at time zero (touchdown).

Altitude (h) and altitude rate ($\dot{h}$) are continuously predicted for the time of touchdown by means of servo techniques. Predicted and desired h and $\dot{h}$ are compared to give an error that, in normal feedback design, slaves the aircraft controls to bring about the desired condition. The process is continuous—the values are predicted constantly for the conditions existing at each instant of flight, and a new command is computed. Another requirement imposed on the system is that the end result be achieved with a minimum of control action.

Figure 2 shows that $\dot{h}$ is compared with the altitude rate desired at touchdown ($\dot{h}_T$) in the inner loop. This error becomes a gain ($\delta(t)_{\dot{h}}$) that is a function of range, or time to go. (The gain increases as touchdown is approached to give tighter altitude rate control.) Predicted altitude (h) is compared with h_T in the outer loop. The resulting errors produce constant control inputs that would bring h and $\dot{h}$ to the desired value at time zero. These inputs are summed to give the command $\delta(t)$. K is a gain constant in the loop.

Second mode is a memory phase

Mode 2 of the approach with the APN-114 is a memory phase. The aircraft is kept in a fixed-attitude descent to around 70 ft. Here the computer calls for a constant normal acceleration on the flight path resulting under ideal conditions, which would be a circular arc. Time measurement in the system is started at the point at which altitude information is deemed reliable.

Longitudinal dispersions measured by Autonetics (with no wind) amount to $\pm$150 ft RMS. With 20 kt,

of headwind, they increased to ±300 ft.

The APN-114 measures height to better than five per cent, or less than 1-2 ft error at touchdown. The sink rate is also measurable within five per cent, with an offset no better than ¼ fps.

The exponential flare path used on the Navaho system was discarded on the APN-114 because Autonetics believes pilots would not "feel right" with its control action. The company also believes vernier control should be provided in the cockpits of aircraft equipped with automatic landing system. This feature, it says, will make pilots accept the whole concept more readily.

Regal a "scanning-beam DME"

Regal is largely a product of Gilfillan's GSN-6 program for USAF. In effect, it is a "scanning-beam DME." So far, only the elevation-measuring system has reached the prototype stage. It is due for tests this month at FAA's NAFEC facility in Atlantic City, N. J.

In its entirety, Regal is an elevation-, azimuth-, and range-determining system. All parameters are determined in the aircraft and used to compute flight control commands. Any of an infinite number of glide paths from ½ to 20 deg could be selected. The system in effect generates a reference grid in space from which any aircraft equipped with the proper electronics may find its position and chose the correct guidance path to touchdown.

Ground microwave transmitters feeding scanning antennas radiate narrow beams for azimuth and elevation guidance. The beams are "notched" with sharp nulls, so that their centers double the system's resolution.

The elevation system operates in X-band, though a higher frequency could be chosen. The ground antenna consists of two linear arrays that are "nodded" simultaneously but in opposite directions between +20 and —0.8 deg in the elevation plane (*Fig. 4*). The scan rate is five per second. While one antenna is nodding downward, the other is returning upward. A coaxial switch lets energy be radiated only during the downward nod. This feature, one of the key elements of the elevation system, lets aircraft discriminate against ground-reflected signals while making low angle measurements.

Each antenna is a linear array of dipole radiating elements. The array is center-fed through a hybrid junction that provides 180 deg phase difference in the RF energies feeding the halves of the array. Destructive interference from each half of the array causes the null at the center of the scanning beam.

In the ground equipment, angle data takeoff signals are fed to the data encoder from a tone wheel pickoff (*Fig. 4*). These signals are converted to coded trigger pulses by the data encoder and routed to the modulator for coding of the RF output pulses.

A receiver on the ground lets the system work as a transponder to range interrogations from the aircraft. Received interrogations are amplified and applied to the data encoder, where they mix with angle data for eventual transmission to the aircraft.

The airborne equipment consists of a receiver-decoder-interrogator and an antenna.

The receiver-interrogator section consists of a cavity-type bandpass filter and circulator, a crystal video detector, and a high gain video amplifier with AGC gated by the decoder. The transmitter uses a low power pulsed magnetron.

For the azimuth system, which has not yet been built, Gilfillan also plans to use a scanning-beam system—which might in effect be the elevation system "lying on its side". The expected angle accuracy is 0.05 deg in elevation and 50 ft in range. System resolution is 0.02 deg.

The APN-114 has been tried out with the Regal elevation system. Reportedly the mating was successful. FAA is expected to test both systems together during its forthcoming evaluation program.

AIL'S system, now in the breadboard stage, is somewhat similar to Gilfillan's. However, it derives range by measuring two angles instead of by DME techniques. In a sense, it can be called a "scanning-beam ILS." Instead of one narrow-beam scanning radar, though, AIL uses two beams radiated from two antennas spaced along a baseline of known length (*Fig. 5*).

On the approach, the airborne equipment first intersects a family of glide slope beams and selects for guidance the one best suited to the plane's flight characteristics and present condition.

The guidance parameter is the glide angle ϕ. The time derivative of ϕ is computed and the aircraft is flown to keep $d\phi/dt$ to zero. (The glide slope thus is a constant, but *any* constant slope can be used.)

As the aircraft proceeds along the glide path, it receives both the glide slope and the flare beams. Distance can then be determined by mechanizing:

$$D=C\tan\psi/(\tan\varphi-\tan\psi).$$

Switch to flare beam guidance

As the flare region is approached—as determined by measurement of D—the system smoothly switches over to the flare beam guidance. Here distance to go is computed by:

$$D=x-Vt,$$

where x is computed distance to go at switchover; V, aircraft ground speed (measured as the rate of change of D until just before switchover); and t, elapsed time from switchover.

Since V is measured just before switchover and not afterwards, it is a predicted quantity. Actually it does not have to be a discrete value but could be made, for more accurate computations, a non-linear function. It could, for instance, be a function of height, which, incidentally, is gotten by AIL by solving:

$$Z=(D+C)\tan\psi.$$

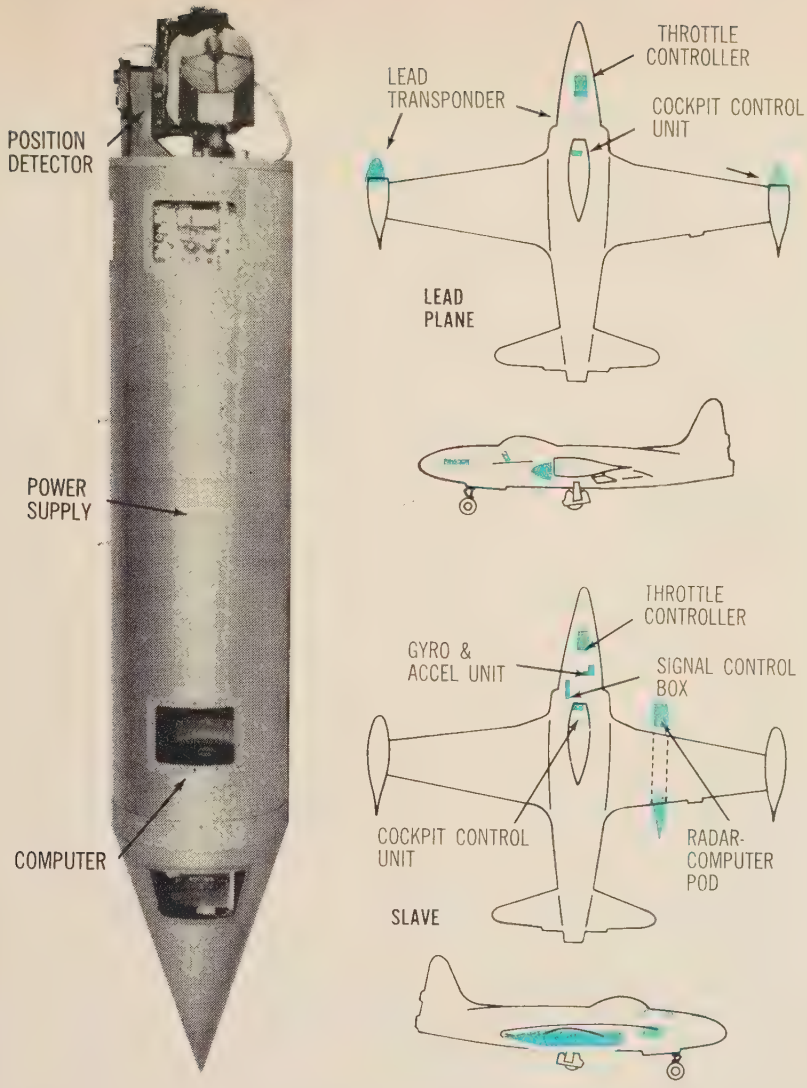
AIL's flareout is computed by mechanizing:

$$dz/dD=mz/D+B,\ (m > 2),$$

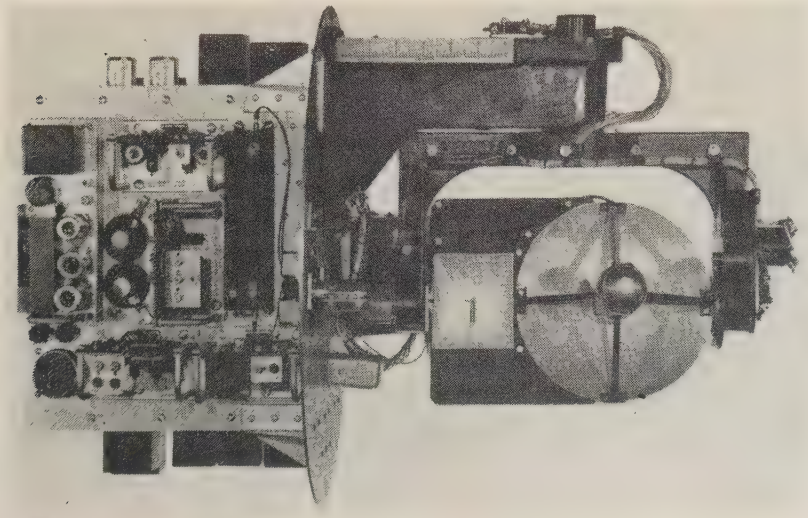
where $m=1+B/F$; D is distance along the centerline of the runway; B, distance from point of touchdown to the point at which a straight glide path intersects the runway centerline; and F, distance from switchover point to the same point of intersection.

This equation represents a family of modified parabolic curves for each of which slope and height above the horizontal decrease with time to go. Both altitude and sink rate become zero at the touchdown point.

Lateral guidance for AIL's system could be supplied by an improved ILAS localizer or a scanning beam in the azimuth plane. This system does not use a notched beam. Instead, track-while-scan techniques resolve the beam center. Half-degree beamwidths are used. The overall accuracy of angle measurement must be 0.05 deg if the automatic landing problem is to be solved in this manner, says AIL. The frequency of the RF system is in the 15-16-kmc range.—End



LOCATION of formation control equipment in lead and slave aircraft (above right). Wing pod of slave (above left) attaches by stand-offs. Flight computer and power supply are packaged in standard containers and need only standard shock mounts. Position detector (below), shown in a cylindrical package, only needs an 18¾-in.-diameter radome for its gimbal structure and a 12-in.-square compartment for the electronics. The system uses the drone's Sperry E-4 autopilot to control the slaves (without curbing the autopilot's normal control functions).



design digest

by Bernard Kovit
Associate Electronics Editor

Drone control system keeps tight formations

PRECISE relative positioning of two or more drones is done automatically by formation control system produced by Armament Div., Universal Match Corp., 472 Paul Ave., St. Louis 21, Mo. Designed for the Lockheed QF-80F, it includes a transponder in the lead drone and a tracking radar in each slave. Relative position is determined from angles made by slant range between lead and slave with each of the slave's axes. Ranging is done by phase comparison over an X-band transmission link. Slave radar's antenna axis gives line-of-sight reference. From this information and inputs from drone autopilot, computer figures deviations from desired coordinate displacements about lead drones and feeds them as control signals to autopilot and throttle controller. Applications include targetry and station keeping for ASW, mine laying, and parachute drops. System adapts readily to various aircraft, including QB-17, F6F-5K, and F9F-6K. Write in No. 72 on Reader Service Card for more information.

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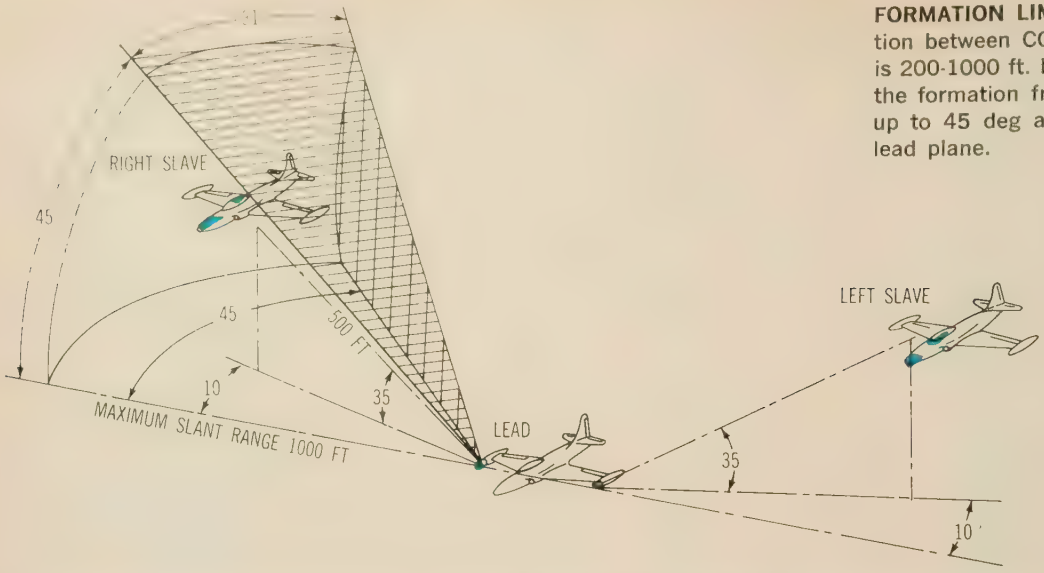
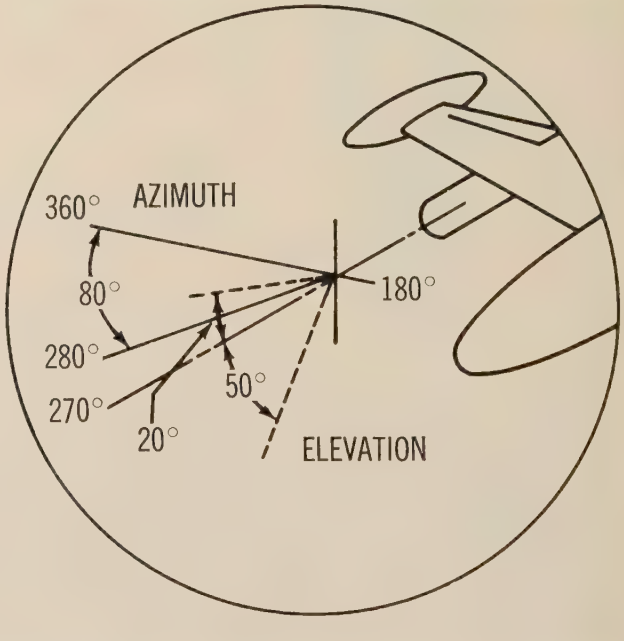
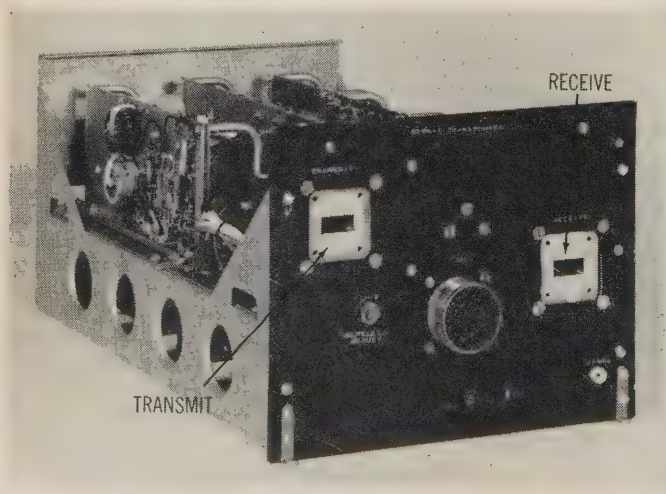
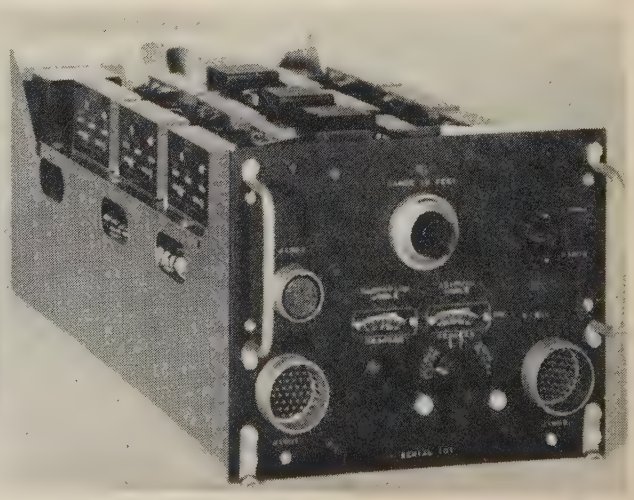


FORMATION LIMITS: Range separation between CGs in lead and slave is 200-1000 ft. Radar visibility limits the formation from wing to wing to up to 45 deg above or behind the lead plane.

SLAVE-RADAR'S angular control limits (right). Position control is accurate to ±10 per cent or ±30 ft (whichever is greater) in level flight. For transients and maneuvers, it's ±25 per cent or ±60 ft. The transponder (below left) mounts in the front cone of the tip tank. Waveguide openings are coupled through flexible connections to rigid antennas fixed to the tank. The same modular card assemblies are used in the transponder and slave position detectors. The slave computer (below right), the brains of the system, resolves slant range and azimuth-elevation angles into lead-drone rectilinear coordinate displacements and compares them with desired values to give formation error signals for autopilot and throttle controller. It also figures a breakaway maneuver for either slave if the radar link between lead and slave is lost or range separation goes below a preset value. After breakaway, the slave comes under the control of a remote director.



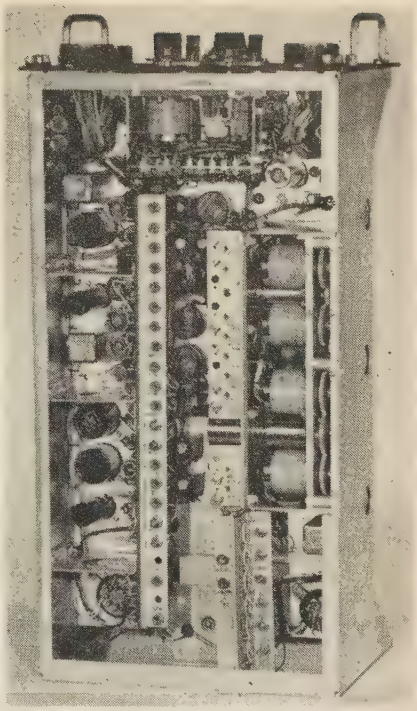




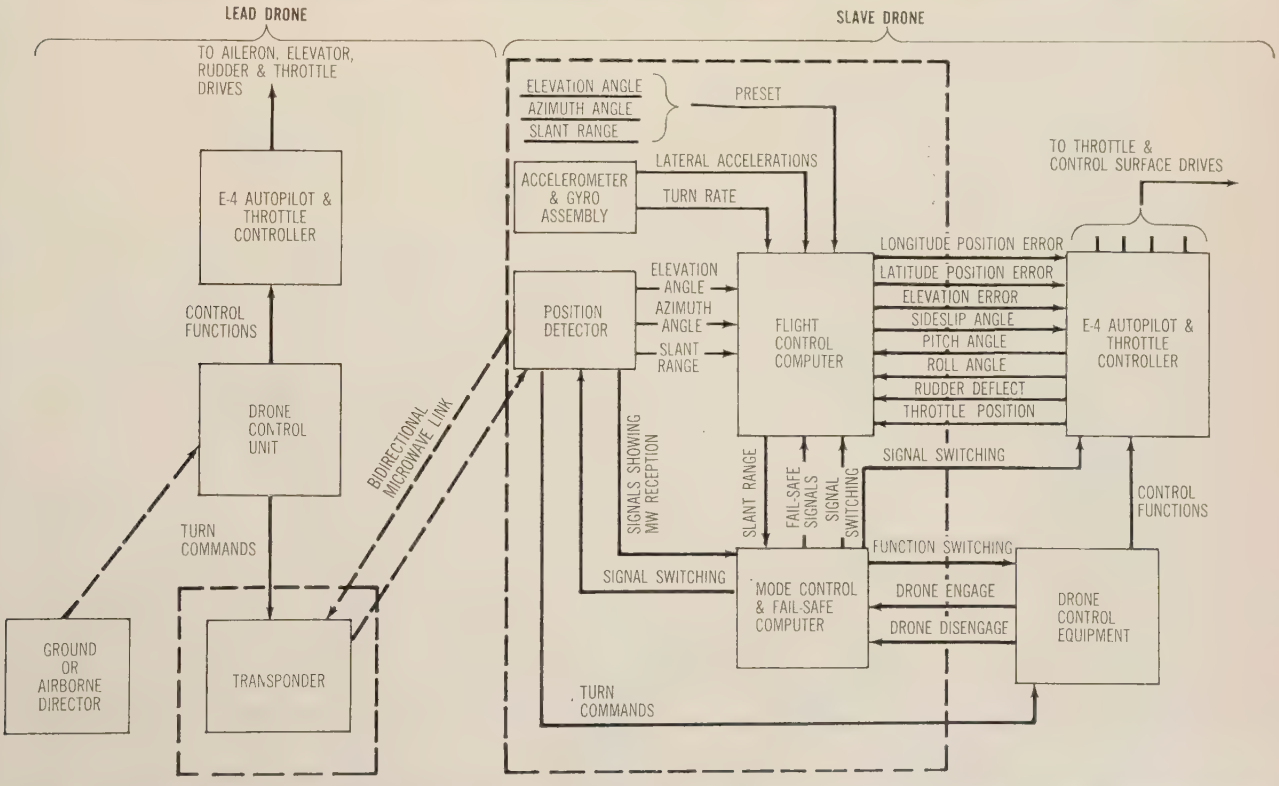
Formation Controller Dimensions

Unit	Size (in.) H	W	L	Weight (lb)
Lead Drone				
Transponder	7¾	10	15½	21
Power supply	7¾	10	15½	30
Throttle controller	2	5¾	11	5.5
Cockpit control unit	2⅜	6	8¼	5.5
Total (3-plane formation)*		1.53 cu ft		113.0
Slave Drone				
Position detector		18¾ dia	25	52
Flight computer	7¾	10	19½	45
Cockpit control unit	2⅜	6	8¼	5.5
Power supply	7¾	10	15½	30
Throttle controller	2	5¾	11	5.0
Signal control unit	4¾	4½	11	8.0
Gyro & accelerometer unit	6⅝	3¾	6½	6.5
Total		5.93 cu ft		152.0

*Total for two-plane formation: 1.53 cu ft and 62 lb.



CLEAN, dense packaging is shown by bottom view of computer. Range and azimuth servos are at right. Row of test points makes for quicker line maintenance.



RELATIVE POSITION is found by measuring slant range and the angles it forms with slave drone's axes. Triggered by lead transponder, slave sends an audio signal on X-band to lead, where signal is amplified and retransmitted on another X-band carrier to slave. Phase comparison of round-trip signal with original reference gives range. Since the tracking radar antenna coincides with line of sight, antenna az-el gives slave's position relative to lead. By commanding lead's maneuvers, remote director controls entire formation.

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Electrokinetic effects

in fluids studied by electronics researchers

by P. M. La Hue, Research Engineer, Minneapolis-Honeywell Regulator Co.*

Electrokinetic effects in fluids were observed as early as 1809, when researchers noted that the passage of electric current through a porous membrane caused water to flow through the membrane. The first qualitative measurements of these effects were made in 1852. Now, a hundred years later, electrokinetic effects are being used to sense acceleration, vibration, and pressure.

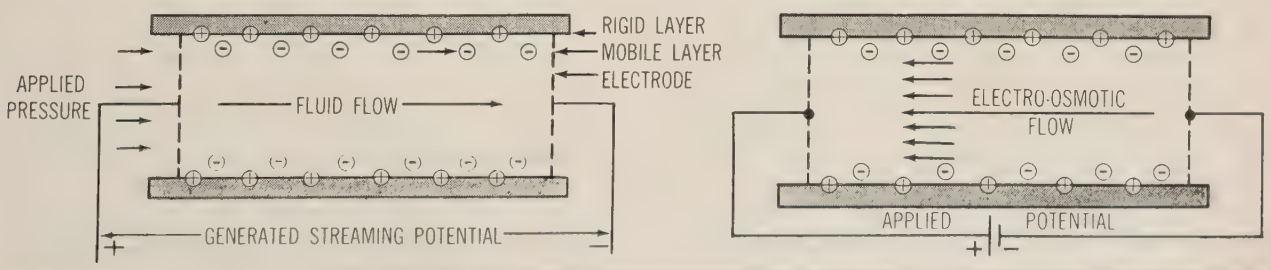
ELECTROKINETICS is that branch of science which deals with the laws of electricity in motion. According to Gaynor's "Concise Dictionary of Science," it studies the motions set up by an applied electromagnetic field and the production of an emf, such as the flow of liquids.

Applied to the movement of ions in solution, electrokinetic research has produced a number of useful de-

* Minneapolis-Honeywell Regulator Co., 2747 Fourth Ave. S., Minneapolis 8, Minn.

more on next page

FIGURE 1: Streaming potential (left). Fluid is forced through the tube by applied hydraulic pressure. Region with excess positive charges is carried along, creating a potential drop from one end of the tube to the other. The magnitude of the streaming potential is directly proportional to the applied hydraulic pressure. Right: Electro-osmosis is the movement of fluid in the tube under the influence of an applied voltage. It is the converse of streaming potential. In unrestricted flow through the tube, the rate of flow is directly proportional to the applied voltage. If the flow is restrained, a hydraulic pressure develops. The pressure will be directly proportional to the applied voltage.



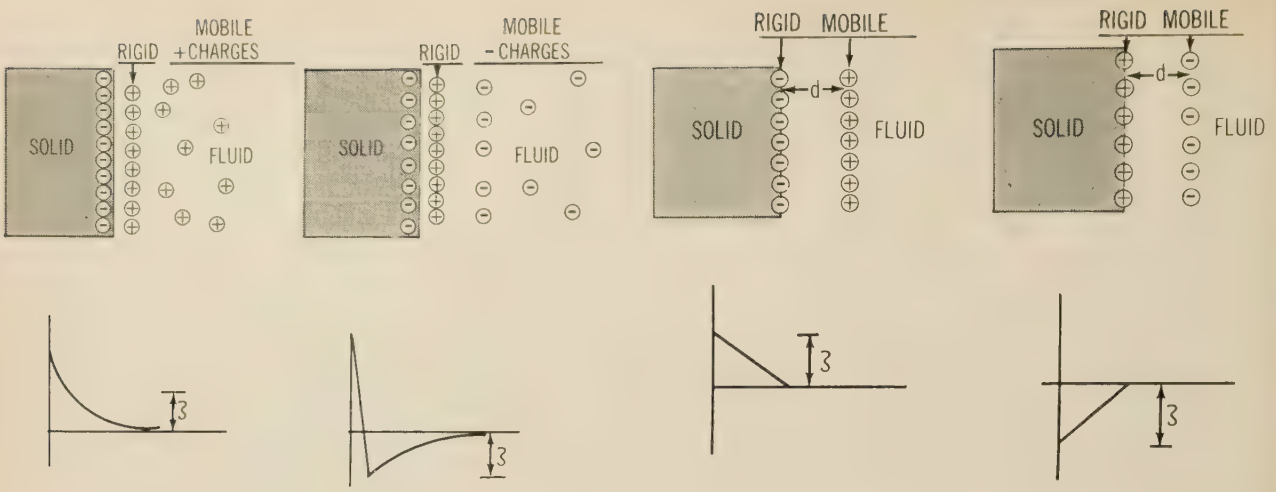


FIGURE 2: Charge distribution (left, top) and potential drop (left, bottom) for that distribution at boundary of solid and liquid solution. Because of unbalanced electric forces, solid has net negative charge and attracts most of the positive ions in solution. Small percentage of total ions is distributed farther into solution and movable with respect to solid. Potential drop through region of movable ions is "zeta potential," on which all electrokinetic phenomena depend. Right: "Characterized" charge distributions (top) and potential drops (bottom). Ions are shown as two parallel layers with net surface charge density of σ coulombs/cm^2 and separated by distance d.

vices; accelerometers, vibrating pickups, and pressure transducers. Many electrokinetics researchers—for instance, at the Naval Ordnance Lab and Minneapolis-Honeywell—believe this field holds a large, untapped potential for military and commercial application. Most of the actual devices based on electrokinetic effects are classified.

When a fluid is in contact with a solid, there is believed to be a charge separation across the interface (*Fig. 2*). The negatively charged solid attracts and tightly holds a layer of positive ions.

Deeper in the fluid there is a diffuse, mobile layer of either positive or negative charges. The charge density of this layer decreases more or less exponentially as the layer extends into the body of the fluid. (Ions of both charges are present, but only the net excess of charge matters.) When the fluid moves, only the charges in the diffuse layer (and not those on the interface) move with it.

Distribution is "characterized"

These charge distributions in the fluid may be thought of as two parallel layers of net surface charge density σ (which might be in coulombs/cm^2) separated by a distance *d*. *Figure 2* shows this "characterized" distribution.

In electrokinetic experiments, the region containing this net charge must be made a significant part of the overall solution. This is done by capillary tubes (which have a high surface volume ratio) or fritted glass disks, which are nothing more than a large number of irregularly shaped capillary tubes in parallel.

The charge separation produces several effects, among them streaming potential, electro-osmosis, electrophoresis, and the Dorn effect:

- *Streaming potential* results when the fluid is moved past the solid surface. The charges in the diffuse layer are swept to the end of the tube charging the electrodes (*Fig. 1*). The magnitude of the streaming potential is directly proportional to the applied hydraulic pressure.
- *Electro-osmosis results* when an electric potential is applied across the capillary (*Fig. 1*). Caused by the electric gradient, the migration of the charged diffuse layer pulls the centerbody of the fluid with it and produces a flow.
- *Electrophoresis* occurs when small particles are suspended in the fluid. A potential gradient across the fluid causes these particles to move (*Fig. 3*).
- *Dorn* effect occurs because of the motion of small, suspended particles (such as in gravitational fall through the fluid) which charges the electrodes (*Fig. 4*).

Potential drop is "ζ potential"

Figure 2 shows the electrical potentials corresponding to the two types of charge distribution and the potentials corresponding to the two characterized distributions of the same potentials. The potential drop from the rigid layer to the body of the fluid (i.e., across the diffuse layer) is the so-called "zeta potential" (ζ). The relationship between σ and ζ may be found by assuming that the system acts as a parallel plate capacitor characterized by σ, ζ, and *d*. The relationship is:

$$\zeta = 4\pi\sigma d/\epsilon, \quad (1)$$

where ϵ is the dielectric constant of the fluid. This equation also holds for long, concentric, cylindrical tubes if the annular separation is small compared with the tube diameter.

The volume rate of the flow (*V*) of the fluid viscosity (η) through a bundle of *n* capillaries—each of which has a length *L* and a radius *a*—that is produced by

Electrokinetic Accelerometer

Minneapolis-Honeywell, which has done considerable research in electrokinetics, recently looked into the possibilities of an electrokinetic accelerometer for inertial guidance. Its findings were negative. Such transducers, says M-H, have been found "entirely inadequate [if] based on the present state of the art and also inadequate [if] based on a [reasonable] extrapolation of the art."

To get accuracies of a few per cent, M-H engineers discovered, impurities and constituents of the fluid would have to be controlled to a precision approaching one part in a million. For such purity, control must be on the order of one part in 10^{12}. M-H found it impossible to attain this control save for very short periods, because the electrolyte "dissolves," or in some manner extracts impurities from container or atmosphere to a concentration greater than one part in 10^{12}.

an applied pressure differential P is expressed as:

(2) $$V = n\pi Pa^4/8L\eta.$$

The velocity (v) of the fluid in a cylindrical shell at a distance r from the center of the capillary is:

(3) $$v = P(a^2 - r^2)/4L\eta.$$

Equations 2 & 3 apply to the flow of an incompressible fluid through a capillary whose length is much larger than its radius.

Equilibrium potential builds up

For a closer analysis of the streaming potential, consider the flow of a fluid through a capillary under an applied pressure P (*Fig. 1*). The charges in the diffuse layer near the fluid tube surface are taken to be negative. The flow of the charged, diffuse layer constitutes a current. Electrodes that do not impede the flow are mounted at each end of the capillary. The potential across the electrodes builds up to an equilibrium potential (v_s), causing a current through both the solution and outside leakage paths (e.g., a potentiometer) that equals the current produced by the fluid flow.

The diffuse layer is at a distance r_d from the center of the capillary, where (*Fig. 1*):

(4) $$r_d = a - d.$$

This layer moves with a velocity (v_d) given by *Equation 3* as:

(5) $$v_d = P[a^2 - (a - d)^2]/4L\eta.$$

Since a is much larger than d:

(6) $$v_d \approx Pad/2L\eta.$$

The charging current (i_c) is given by:

(7) $$i_c = 2n\pi r_d v_d \sigma \approx n\pi Pa^2 d\sigma/L\eta.$$

Substituting for σ from *Equation 1*, we get:

(8) $$i_c = n\pi Pa^2 d\sigma/L\eta.$$

If the resistance between the electrodes is R, the potential at equilibrium v_s is given by:

(9) $$v_s = iR,$$

where i is the leakage current from electrodes. For equal but opposite charging and leakage currents:

(10) $$v_s = nPa^2\epsilon\zeta R/4L\eta.$$

If the only leakage from the electrodes is through the fluid and ρ is the volume resistivity of the fluid, then:

(11) $$R = \rho L/n\pi a^2,$$

(12) $$v_s = P\epsilon\zeta\rho/4\pi\eta.$$

From *Equation 12*, we can see that the generated streaming potential (v_s) is:

- directly proportional to P, ϵ, and ρ;
- inversely proportional to η;
- independent of the capillary dimensions and the number of capillaries.

Ceramic frit for low flow rate

The magnitude of the streaming potential is neither a function of the capillary dimensions nor of the number of capillaries; the volume flow rate needed to maintain a specific streaming potential is such a function (see *Equation 2*). If a low flow rate is desired, the capillary radius must be small and the capillary length long. A ceramic frit, which may be considered a bundle of capillaries, conveniently produces this result.

The working fluid should have a high dielectric constant, high volume resistivity, and low viscosity. However, the zeta potential is a function of the contacting surface as well as of the fluid, and is not well characterized. It is determined by solving *Equation 12* for ζ and measuring the streaming potential.

Zeta potentials range from about –0.05 to 0.05 V when the value of the dielectric constant for the bulk fluid is used in *Equation 12*. In principal, the dielectric constant of the fluid near the interface should be used. There is also a certain surface conductivity at the interface, caused by the increased concentration of ions in this region. The smaller the capillary, the more important is this effect.

Equation 12 may be expressed in the form:

(13) $$v_s = 6\times10^{-7}P\epsilon\zeta\rho/\eta \text{ volts},$$

where P is in psi, ζ in volts, ρ in ohm-cm, and η in centipoises. For water at 25 deg C (77 deg F) against glass, $\epsilon = 79$, $\zeta \approx -0.05$ V, $\rho \approx 10^5$ ohm-cm, $\eta = 1$ centipoise, and $v_s \approx 0.24$ V/psi. For acetonitrile, (methyl cyanide) at the same temperature against glass, $\epsilon = 37$, $\zeta \approx 0.05$ V, $\rho \approx 10^5$ ohm-cm, $\eta = 0.35$ centipoise, and $v_s \approx 0.31$ V/psi.

Centerbody of fluid attains v_d

As we now turn to electro-osmosis, consider a fluid in a capillary with a charge density σ in the diffuse layer near the fluid-tube interface (*Fig. 1*). If an electrical potential (v_o) is impressed across the capillary, the potential gradient (v_o/L) produces a force on the diffuse layer. This layer, being mobile, attains a velocity v_d. At equilibrium, the centerbody of the fluid also attains this velocity, the velocity of the fluid as a function of its distance from the center of the capillary being:

(14) $v \approx v_d$, $0 \leq r \leq (a - d)$; $v \approx v_d\,(a - r)/d$, $(a - d) \leq r \leq a$

V for n capillaries is:

(15) $$V \approx n\pi a^2 v_d.$$

The force on the diffuse layer that is due to the potential gradient is:

more on next page

(16) $= 2\pi(a - d)L\sigma v_o/L$, or

(17) $f \approx 2\pi a\sigma v_o$.

The viscous shear resistance across the annular space between the diffuse layer and the tube wall is approximately:

(18) $f = 2\pi aL\eta\delta v/\delta r$, or

(19) $f \approx 2\pi aL\eta v_d/d$.

From *Equations 17 & 19*, we get:

(20) $v_d = \sigma d v_o/L\eta$.

After substitution for σ and v_d from *Equations 1 & 20*, respectively, *Equation 15* can be written as:

(21) $V = na^2v_o\epsilon\zeta/4L\eta$.

Porosity varies with use

If the fluid is constrained so that there is no net flow through the capillary, a pressure differential (P_o) will be produced across the capillary. It causes a counterflow that is superimposed on the electro-osmotic flow. The flow volume rate due to the pressure is found from *Equation 2:*

(22) $V = n\pi P_o a^4/4L\eta$.

For no net flow, we get:

(23) $P_o = 2v_o\epsilon\zeta/\pi a^2$.

For pump applications, we can see from *Equation 21*, the working fluid should have high dielectric constant and low viscosity, and the capillary bundle (e.g., a ceramic frit) should be highly porous and thin. In a pressure producing design, *Equation 23* shows, the working fluid should have a high dielectric constant and the frit, or capillary bundle, should have small pores. What we have said about the zeta potential in our discussion of steaming potential also applies here.

Equation 21 may be expressed in the form:

(24) $V \approx 3 \times 10^{-18} na^2v_o\epsilon\zeta/L\eta$ cm³/sec,

where a is in microns, γ_0 and ζ are in volts, L is in centimeters, and η in centipoises. *Equation 23* may be expressed in the form:

(25) $P_o \approx 0.01v_o\epsilon\zeta/a^2$ psi,

using the same system of units as in *Equation 24.*

A typical sintered-glass frit might have a diameter of one centimeter, a path length of one centimeter, pores of one micron radius, and a free space of 25 per cent. For this frit, $a = 1$ cm, $L = 1$ cm, and $n \approx 1.2 \times 10^7$. For water at 25 deg C against glass and using this frit, $\epsilon = 79$, $\zeta \approx -0.05$ V, $\eta = 1$ centipoise, giving:

(26) $V \approx 1.4\times10^{-4}$ cm³/sec per volt,

(27) $P_o \approx 0.04$ psi/volt.

For acetonitrile (methyl cyanide) at 25 deg C against glass and using the same frit, $\epsilon = 37$, $\zeta \approx 0.05$ V, and $\eta = 0.36$ centipoise, giving:

(28) $V \approx 1.8\times10^{-4}$ cm³/sec per volt,

(29) $P_o \approx 0.02$ psi/volt.

Experiments uphold relation

The electric current flowing through the electro-osmotic cell is given by:

(30) $i = n\pi a^2v_o/\rho L$.

The ratio of (unconstrained) electro-osmotic flow to the current passing through the cell then is:

(31) $V/i = \epsilon\zeta\rho/4\pi\eta$.

From *Equation 12*, the ratio of the streaming potential to its generating pressure is:

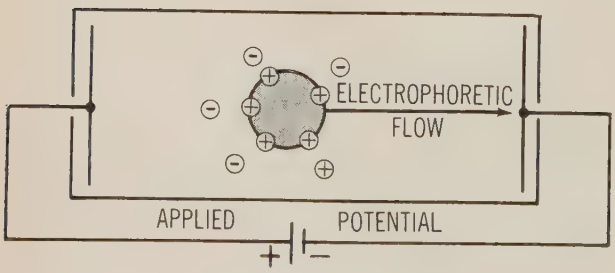
(32) $v_s/P = \epsilon\zeta\rho/4\pi\eta$.

So, for a given fluid and frit, we find:

(33) $(V/i)_{\text{electro-osmotic}} = (v_s/P)_{\text{streaming potential}}$.

This relation can be experimentally verified.—End

FIGURE 3: Electrophoresis occurs when particles suspended in the fluid move under the influence of a potential across the fluid.



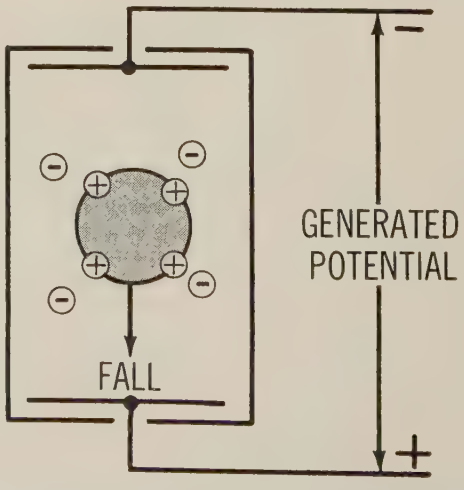
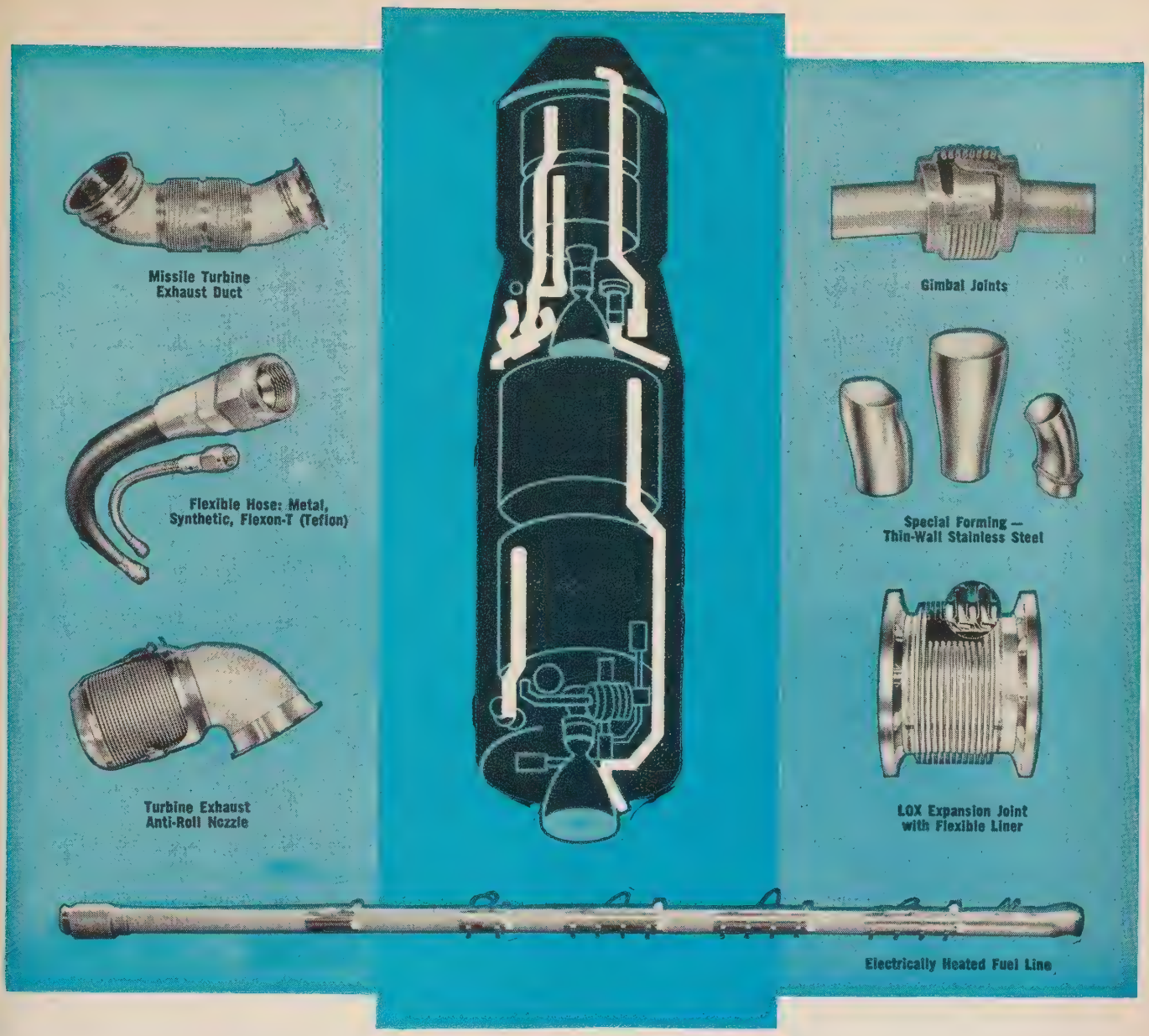


FIGURE 4: The Dorn effect occurs when particles fall through the fluid. The motion charges the electrodes.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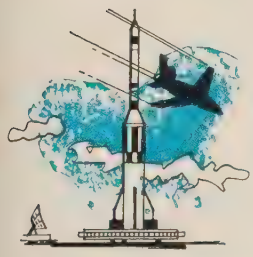

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Flexonics Research Laboratories, Elgin, Illinois

In Canada: Flexonics Corporation of Canada, Limited, Brampton, Ontario

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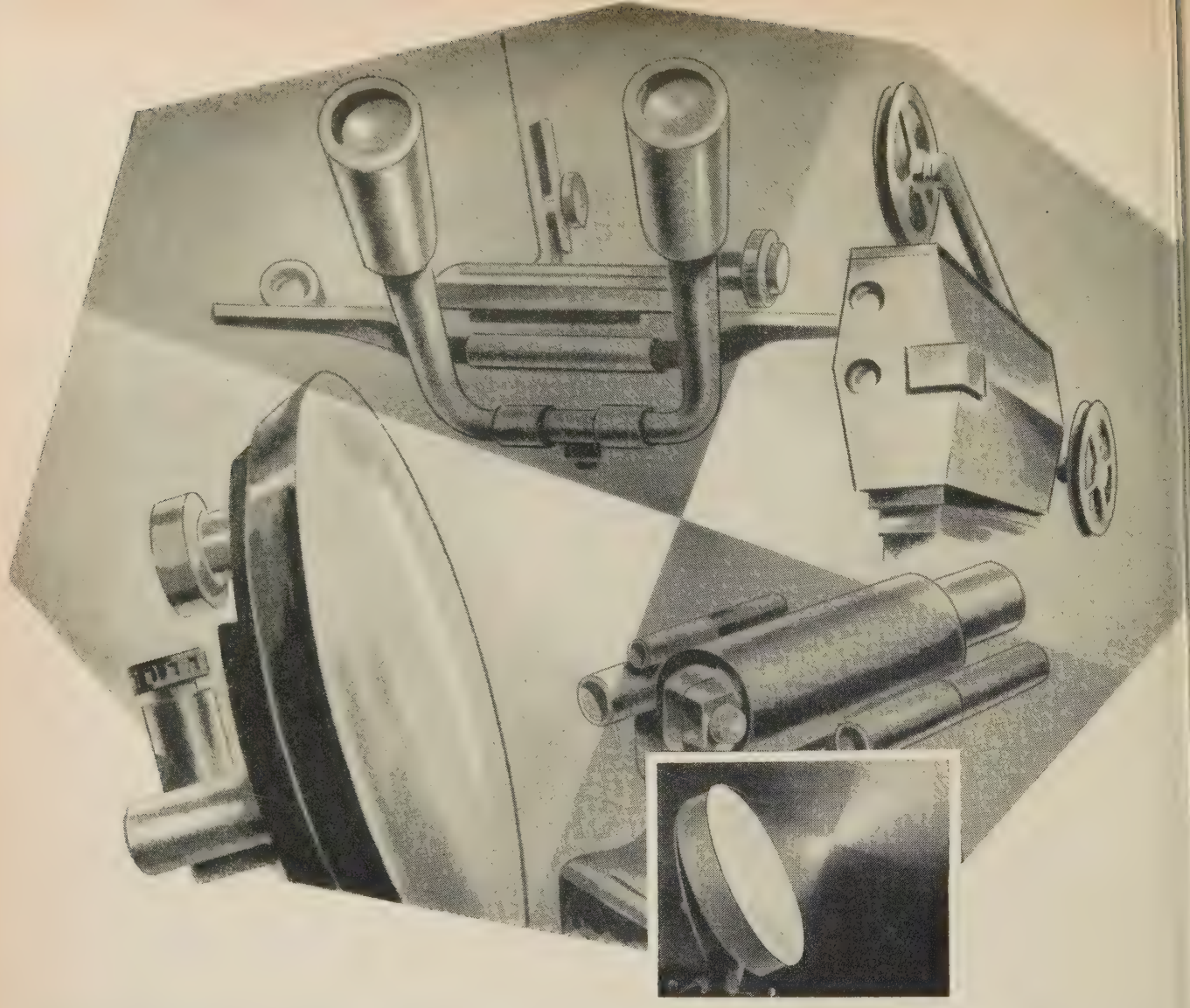

Unbreakable Repli-Kote Mirrors out-perform glass, slash costs

These new lightweight, low distortion Repli-Kote Mirrors of cast epoxy resin offer design engineers optical reflectors with a matchless combination of properties, impossible with glass. A single master mirror is all that's necessary for mass producing precision Repli-Kote Mirrors—at significant cost savings.

Optical Precision — 6″—5¼″ Focal Length Repli-Kote paraboloid mirrors have been produced in quantity with an accuracy permitting 90% of incident collimated light to be concentrated within a disc of 0.1 mm diameter. Higher rate of thermal diffusion through epoxy also lowers distortion caused by temperature transients.

Permanent Reflective Surface — High vacuum applied, silicon monoxide protected aluminum reflective surface is *permanently* bonded to epoxy backing, will resist flaking or peeling for extended periods.

High Mechanical and Thermal Shock Resistance — Repli-Kote Mirrors have withstood impacts *as severe as 22,000 g*, undergone rapid temperature cycling from −55°C to +125°C with no measurable physical change.

Light Weight—Repli-Kote Mirrors cast of epoxy are much lighter than glass. Suitable fillers can be added if desirable.

Any Shape—Paraboloids, hyperboloids, ellipsoids and more complex aspheric surfaces not previously reproducible in glass by mass production methods can now be quickly fabricated.

Ease of Mounting—Fixtures, threaded inserts, electrical components can be molded directly into the mirror backing, opening an almost limitless field of design possibilities. Repli-Kote Mirrors are also easily machined.

If you are working on tracking and guidance systems—or any system employing reflective optics—durable, lightweight, precision Repli-Kote Mirrors offer you greater design and production freedom. Let us help you make the most of Repli-Kote Mirrors in building a better product at lower cost.

Address Inquiries *to Repli-Kote, Singer-Bridgeport, 915 Pembroke Street, Bridgeport 8, Conn.*

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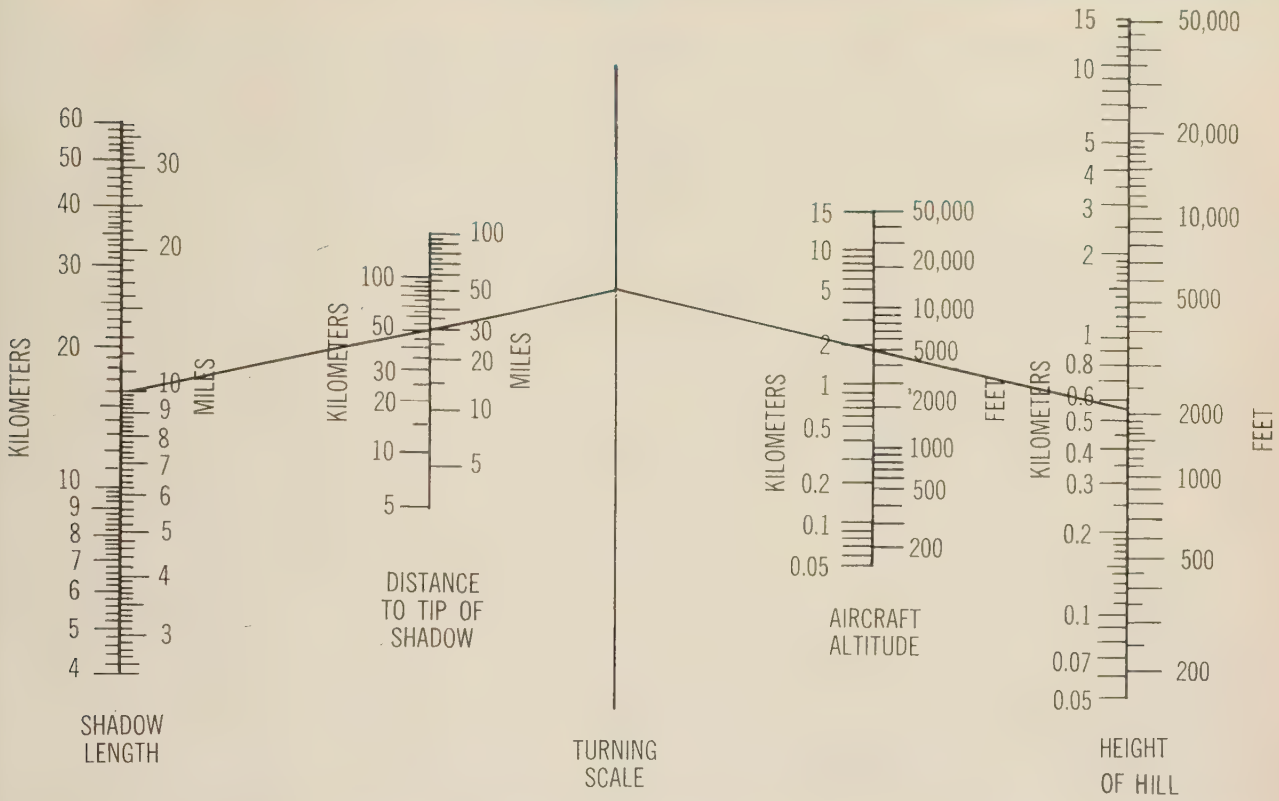
Pages from an Engineer's Notebook



Finding height from radar shadows

by Donald Moffat, Senior Electronics Designer, Motorola, Inc.*

THE height of hill and tall structures can be determined from radar maps. Often, though, this opportunity is neglected because of the calculations involved in the process. This *Nomograph* greatly simplifies the job—it uses the shadow characteristic of radar maps to find height without calculations.

Sample Problem—Assume a map made from an aircraft flying at 5000 ft. On this map, a hill 20 miles away casts a 10-mile-long shadow. The horizontal distance from the aircraft to the shadow tip is 30 miles.

To find the height of the hill on the *Nomograph,* draw a line through 10 miles on the *shadow-length* scale and 30 miles on the *distance-to-tip-of-shadow* scale and extend it to the *turning scale.* From the point of intersection on the *turning scale,* draw a line through 5000 ft on the *aircraft-altitude* scale, extend it to the *height* scale, and read 2200 ft for the height of the hill.

If there is an area of special interest, the *Nomograph* can be used in the reverse direction to give paths that will keep the area from being lost in the shadow.—End

* Motorola Inc., Western Military Electronics Center, 8201 McDowell Rd., Phoenix, Ariz.

What are your needs in Seamless Tubing?

A-L offers widest range of materials and large diameters with walls as thin as .032".

Here is the widest range in materials in stainless seamless tubing available anywhere to meet your exact requirements and solve high-temperature or corrosion problems and save you money.

Allegheny Ludlum makes seamless tubing in all stainless grades including 309, 317, 318, 310, 416 and 446—normally difficult to obtain. Also available in high-strength alloys such as A-286, in vacuum melted steels, and in custom analyses grades such as low cobalt with .01 or .05 max. and small boron additions to standard types.

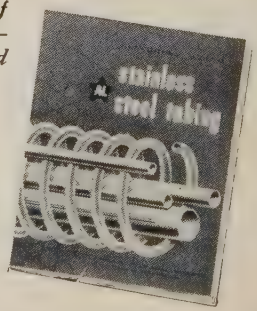
A-L also makes composite tubes with bonded combinations of carbon and stainless and other metals for special chlorine-corrosion applications in process equipment.

Allegheny Ludlum Stainless Tubing ranges from 3/16" OD to 3½" OD with wall thickness ranging from .013" to .375"—typical of the sizes that A-L can produce. For certain applications, .500" walls are possible. Some standard sizes in stock are 2½" OD—.032" walls, 3" OD—.042" walls and 3½" OD—.042" walls and 3½" OD—.058" walls. All sizes with true circularity, no dents or handling marks.

A-L Tubing is also available in small quantity orders, in random or cut lengths. Standard grades and sizes in stock throughout the country. Call your nearest A-L representative for all the help you need.

Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa. Address Dept. AV-21

NEW! FREE—Write for your copy of Allegheny Ludlum Stainless Tubing—32-pages of technical data, grades and suggested applications.



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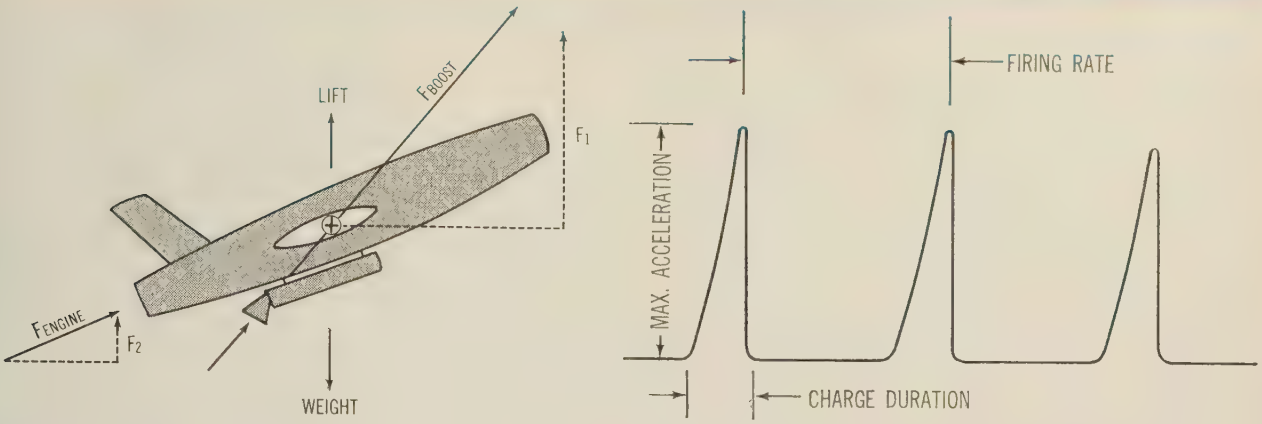


MISSILE LAUNCH DYNAMICS (left). Shock conditions are set up when engine and booster exert forces to overcome the weights of the missile just coming off the launch rails. (F_1 and F_2 represent the vertical components of the vector forces). Right: Typical trace of a primary wave produced by the repeated vibration shock of gunfire in an aircraft, which is analogous to a series of blows with a hammer.

How bad is the shock and vibration flight environment?

Here are some data on shock and vibration that should prove highly useful to electronics designers. They cover in detail the operating environments of the Navy's line aircraft and non-ballistic missiles.

by David D. Blair,
Sr. Project Engineer, Robinson Technical Products, Inc.*

UNDER NORMAL conditions of turbojet- or rocket-powered flight, the Navy's experience shows, vibration in military aircraft seldom exceeds ±2 g from five to 500 cps in any particular direction. This is an average figure, since the severity of vibration excursions is inversely proportional to the distance from the source of excitation. For instance, accelerations recorded directly on the engine may be as high as ±40 g. As this vibration is transmitted through the structure, it is damped by internal material action and structural slippage (in riveted or bolted structure) and attenuated.

Structure in the immediate area of the exciting source might reach ±10 g, ±5 g (10-15 ft), ±2 g (15-30 ft), or ±0.5 g (30-90 ft). These values are estimates and depend greatly on the amount of imbalance or uneven burning, of the excitation source, which may be assumed to be some propulsion device.

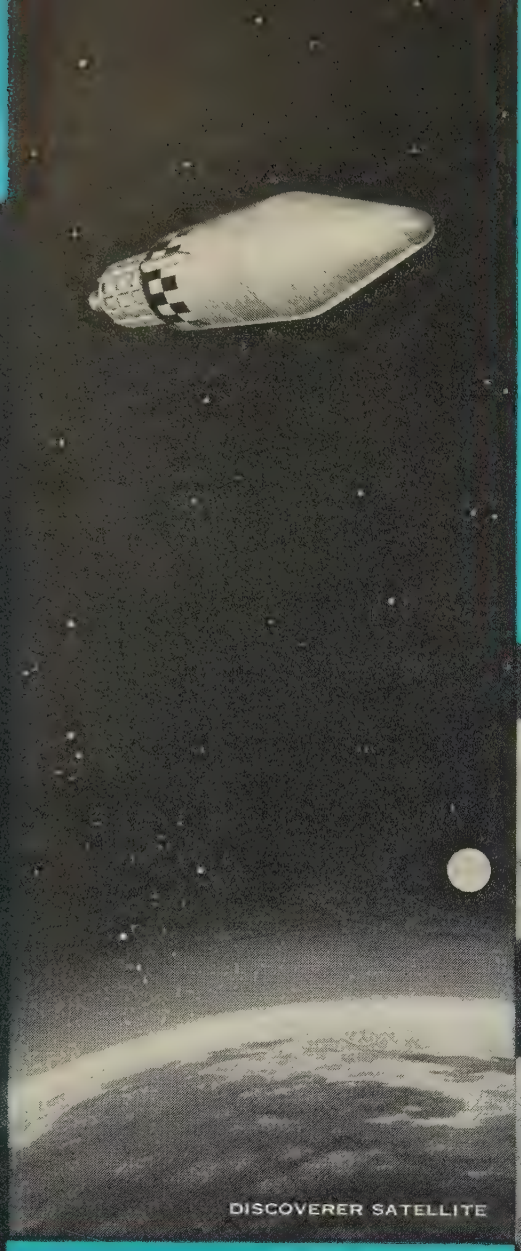
Vibration, though usually transient, can be broken down into frequency bands and average acceleration (excursion) forces in each band, as for example:

- *2-100 cps*—This range contains prime and secondardy bending and torsional modes of the fuselage and wings. Modes involving over 100 cps become extremely complex, and excursions or acceleration are very low. (Though stabilization systems are designed for zero vibration, they usually respond up to 25 cps. This response can accentuate prime and secondary bending modes.)
- *5-500 cps*—This range usually stems from the propulsion source and its harmonics. Severe buffeting and gunfire vibration are also in this range.
- *500-2000 cps*—This range contains acoustic vibration from rocket blast or high tip speeds of turbines (scream). Since recording equipment is unreliable over

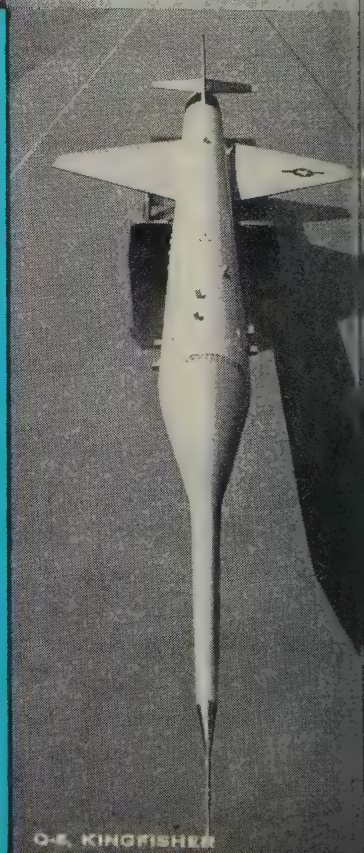
more on page 172

* Robinson Technical Products, Inc., 604 Colorado Ave., Santa Monica, Calif.

POLARIS FBM



DISCOVERER SATELLITE



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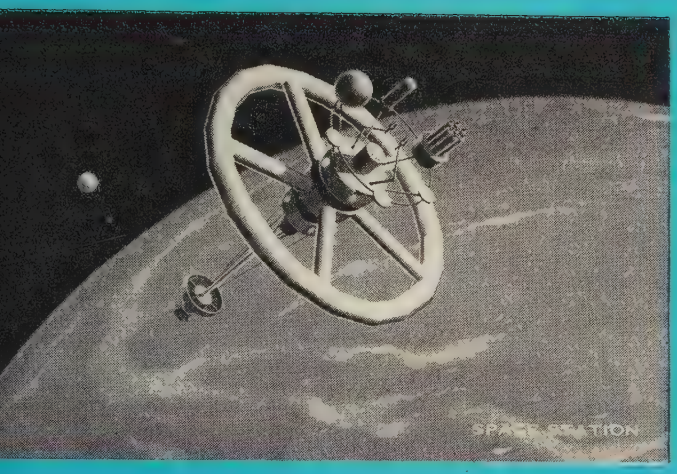

EXPANDING THE FRONTIERS OF SPACE TECHNOLOGY

■

ADVANCED PROJECTS AT LOCKHEED

POLARIS FBM—Lockheed is missile systems manager for the Navy POLARIS Fleet Ballistic Missile, under the cognizance of the Special Projects Office of the Bureau of Ordnance. Submarine-launched, the POLARIS will travel through three mediums in a single flight: water, air and outer space. With three-quarters of the earth's surface being water, practically no target in the world is outside its range. The solid-propellant POLARIS was *designed with the future in mind*—an approach that the Navy states has cut nearly two years from the original timetable.

DISCOVERER SATELLITE; MIDAS; SENTRY Designed and built by Lockheed Missiles and Space Division, the first of a series of DISCOVERER satellites was successfully placed in orbit in February. The Division has also been assigned the responsibility of systems manager for PROJECT MIDAS—an early warning system against ballistic missile attacks. The project will investigate the use of infrared sensors for detecting aggressor missiles at the moment of launch; and PROJECT SENTRY—an advanced satellite reconnaissance system. DISCOVERER, MIDAS and SENTRY are programs of the Advanced Research Projects Agency under the direction of the Air Force Ballistic Missile Division.

X-17—The nation's first successful reentry tests were conducted by the Air Force with the three-stage, Lockheed X-17 solid-propellant ballistic missile. The X-17 has pioneered many new techniques and the valuable experience gained from this program has facilitated development of other, inter-service projects, including the Navy POLARIS FBM. The Navy's history-making, 300-mile-high, Project Argus radiation explosions featured the X-17 as the vehicle.

Q-5, KINGFISHER—Developed for the Air Force, and currently being manufactured for the Army, the Kingfisher is designed to simulate enemy attacks to test the efficiency of our various defensive weapon systems. It is equipped with extensive instrumentation to register "kills" without itself being destroyed and can be recovered by parachute and landing spike to be used again, with marked savings in cost.

X-7—Lockheed's X-7 recoverable ramjet-engine test vehicle, developed for the Air Force, has established speed and altitude records for air-breathing vehicles and is also recoverable for re-use following flight.

SPACE STATION—An orbiting research facility, to serve as an advance base for space exploration, has been proposed in practical detail by Lockheed's research and development staff. The station would carry a 10-man crew. Prefabricated compartments for the rim of the wheel, the spokes, and the three hubs would be launched separately by means of ballistic missiles and guided into a cluster on the same orbit.

The successful completion of projects such as these requires a bold and imaginative approach to entirely new environments. Lockheed's programs reach far into the future. It is a rewarding future which scientists and engineers of outstanding talent and inquiring mind are invited to share. Write: Research and Development Staff, Dept. I-16, 962 W. El Camino Real, Sunnyvale, California. U.S. citizenship required.

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from page 169

this range, the frequency limits are questionable. Accelerations usually are on the order of ±20 to ±60 g.

Gunfire is a major problem in aircraft vibration. Primarily it sets up a repeated shock condition analogous to several hammer blows (see *Trace*). Each shock excites the surrounding structure at its natural frequency (and harmonics) if the natural frequency of the structure is equal to or less than the frequency calculated from the rise time of the shock pulse. Since the shocks are repeated, the initial vibration is extended or reduced in magnitude, depending on the phase relationship of the exciting source.

Transmitted vibration may run to +60 g

An extremely complex wave results. Though the initial accelerations from two 20-mm cannon are about ±25 g, transmitted vibrations can run as high as ±60 g. Frequency ranges are vague. Prime frequencies run from 16.6 cps for electric-charge 20-mm cannon to 100 cps for General Electric's Gatling guns.

Secondary vibration problems in aircraft are due to large excursions of wings and fuselage from buffeting. Wings and tail, being cantilever members, feel the greatest effects. If a nose boom is added, the nose section is also affected. The main fuselage feels little effect.

The frequency range is usually the 2-100 cps span of prime and secondary bending conditions. The excursions run into inches for low frequencies (2-100 cps) and are proportionately less for higher frequencies. Most affected parts are lights, antennas, and hydraulic equipment in wing tips and tail surfaces.

Meters, relays, pots, and wires give trouble

Engine-excited vibrations are tertiary problems. Most engines and engine parts are designed to meet the expected environments. Electronic equipment, which is most affected, is usually far removed from the vibration sources. Meters, relays, potentiometers, and wire give the most trouble, as in general do all components containing moving mechanisms.

more on page 174

THE FINE ART OF TRACKING and recording data from the nation's newest missiles is the task of the newly outfitted USS American Mariner—operating in the waters of the Atlantic Missile Range. Advanced electronic equipment aboard includes CEC DataTape 5-681 Digital Recorder/Reproducers. Employing all solid-state electronics, the units feature 5-millisecond start and stop times, 0.05″ tape positioning accuracy, 10½″ NARTB reels, and complete front accessibility. Transport fits standard 19″ relay rack. Two types provide tape speeds to 30 and 150 ips. For more information, call your nearest CEC sales and service office, or write for Bulletin CEC 1618-X 7.

DataTape Division CEC

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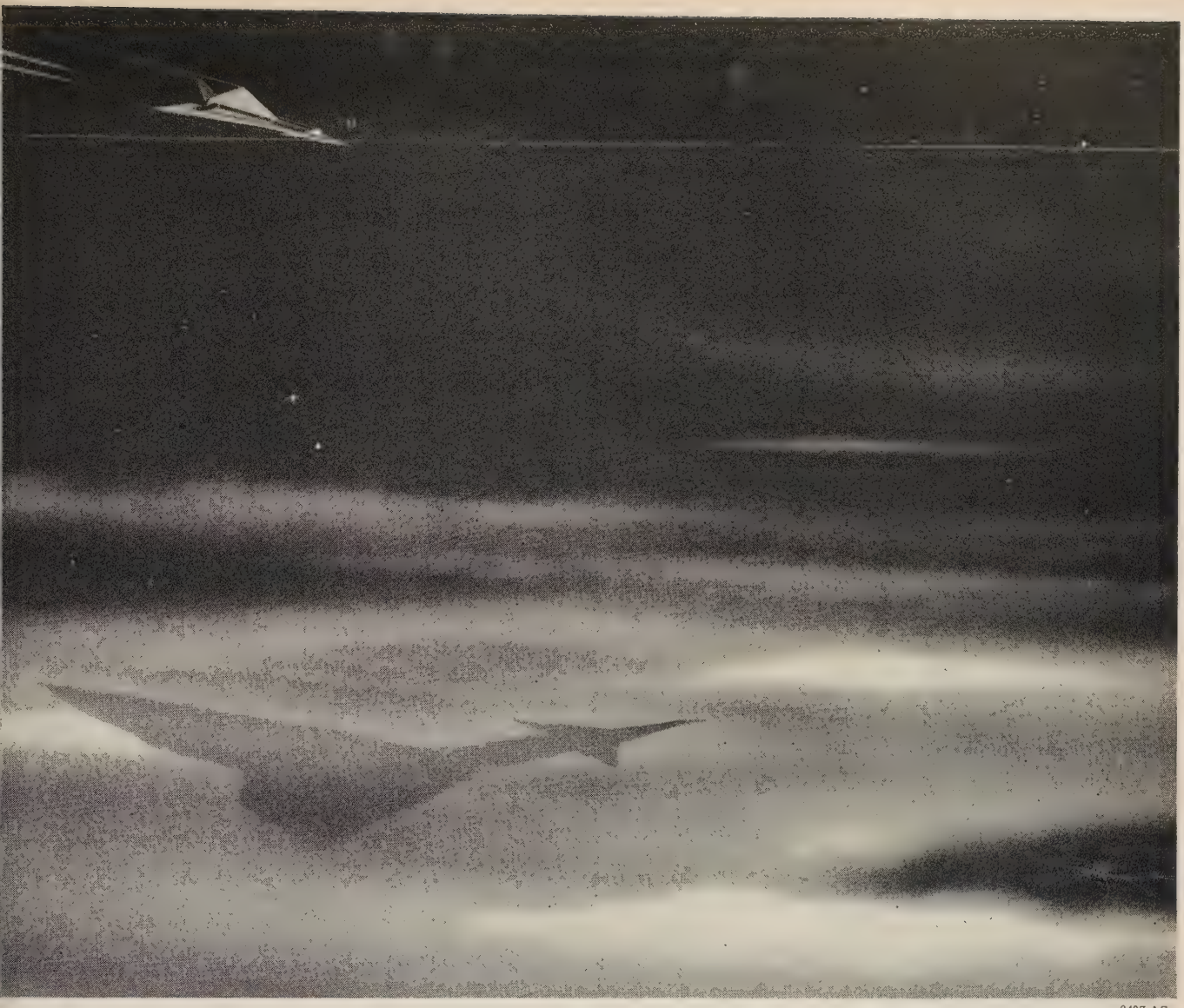

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To meet the critical demands of Mach 3 performance, new concepts in air vehicle structures have been evolved. Stainless steel honeycomb sandwiches, for example, are specified as major structural components in current weapons systems designed to operate in high mach environments.

Aeronca, a pioneer in the application of stainless honeycomb to air weapons, has developed advanced production methods and facilities under a proprietary research and development program. As a result, Aeronca is one of the few companies actually producing these high-temperature structures in quantity.

Aeronca is proud that its capabilities have been selected to support the North American B-70 and F-108 Weapons Systems.

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Expansion of our operations has created openings for additional senior engineers. Write to L. C. Wolfe, Chief Engineer.

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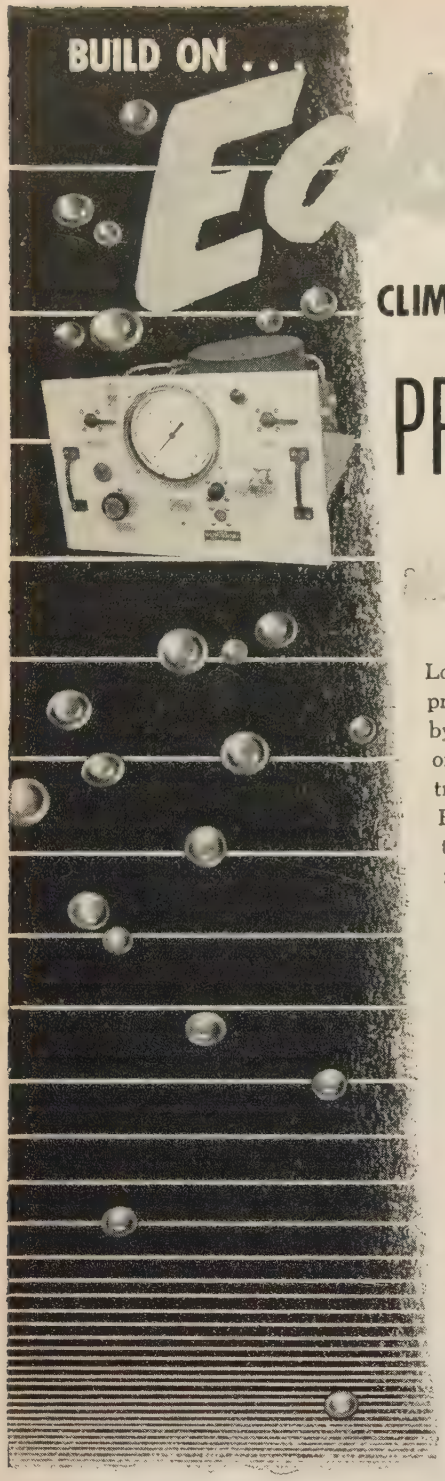

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PRESSURIZATION
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Look to Eastern Industries for the advanced pressurization/dehydration packs required by the avionic and ground support systems of tomorrow. Whenever a precisely controlled flow of dehydrated air is required, Eastern design and production experience team up to create compact, lightweight, reliable subsystems. Characteristics and performance range of existing units:

Characteristics and performance range of existing units:

capacities: up to 1.5 FT^3/Min. free air

operating temperatures: from −67°F to +150°F, 100% R.H.

operating altitudes: from 10,000 ft. to 50,000 ft.

weights: from 8 lbs. to 115 lbs. complete

Smaller packs feature replaceable chemical dehydrator elements — the larger subsystems are available with automatic reactivating dehydrators.

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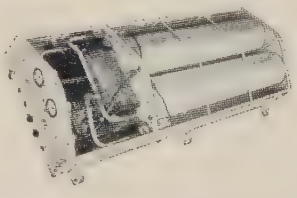
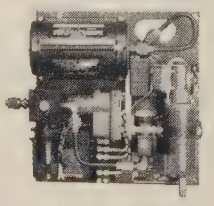
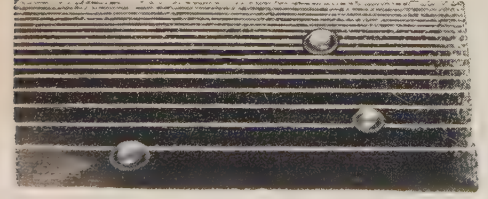




a wide range of units for specialized air control



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Combined environmental effects of a unique kind occur in high speed aircraft that launch missiles. To cut down external drag, which would reduce aircraft performance, these missiles are carried in pockets in the airframe. During launch, they are extended from the airframe by crank arms and cylinders. The extension of the missile into the supersonic slipstream leads to severe shock loading and buffeting of the crank arms and cylinders, which transmit the loads directly to the airframe. In addition, the propulsion system of the missile is ignited and, until the missile is released, transmits vibration through the arms to the airframe. Shock loading is estimated to run as high as 90 g for 1-2 millisec. The vibration environment to date has not been determined or estimated.

Six-g acceleration in catapult launch

Carrier landings and catapult launches involve a variety of shock and acceleration stresses. The 15-g, 11-millisec sawtooth pulse generated by a modified 150 VD sand drop table simulates a hard carrier landing fairly closely. During catapult launch, a steady-state acceleration of about six g is exerted along the longitudinal axis of the aircraft for several seconds.

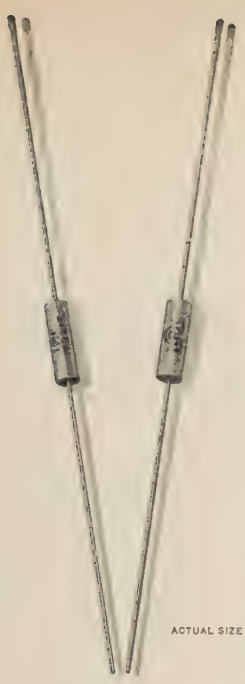
Vibration in non-ballistic missiles during normal flight is about the same as in aircraft, the Navy's experience shows. Again, the severity of vibration depends on location with respect to the excitation source, the amount of imbalance and force of the excitation source, etc. The main difference between missiles and aircraft lies in the type of launch. Also, of course, missiles do not have guns.

Bending and torsional modes higher

Primary bending and torsional modes are slightly higher in missiles than in aircraft, because of the absence of high lift wings. Also, thanks to the speed of missile takeoff, flight, and landing, no large stabilization surfaces are needed. Primary bending and torsional modes are increased to about six cps (with the same 100-cps limit that applies in aircraft).

The periods just before and dur-

more on page 178



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Small-World Resistors with out-of-this-world Reliability

Miniaturization is a severe test of performance, for reliability tends to shrink faster than size. Here, where critical equipment had to be made smaller, yet more reliable, Bendix-Pacific pinned performance to the reliability of IRC precision film resistors.

IRC Molded Metal Film Resistors combine excellent stability on load with a low, controlled temperature coefficient that is far superior to other precision film resistors. They exceed requirements for extremely close design tolerances and have excellent high frequency characteristics. Where these superior characteristics are not required, IRC Molded Deposited Carbon Resistors offer excellent all-around performance and economy. Both types available in ⅛, ¼, ½, 1 and 2 watt sizes . . . and exceed MIL-R-10509B specifications. For design data, write for Bulletins B-3 and B-9.

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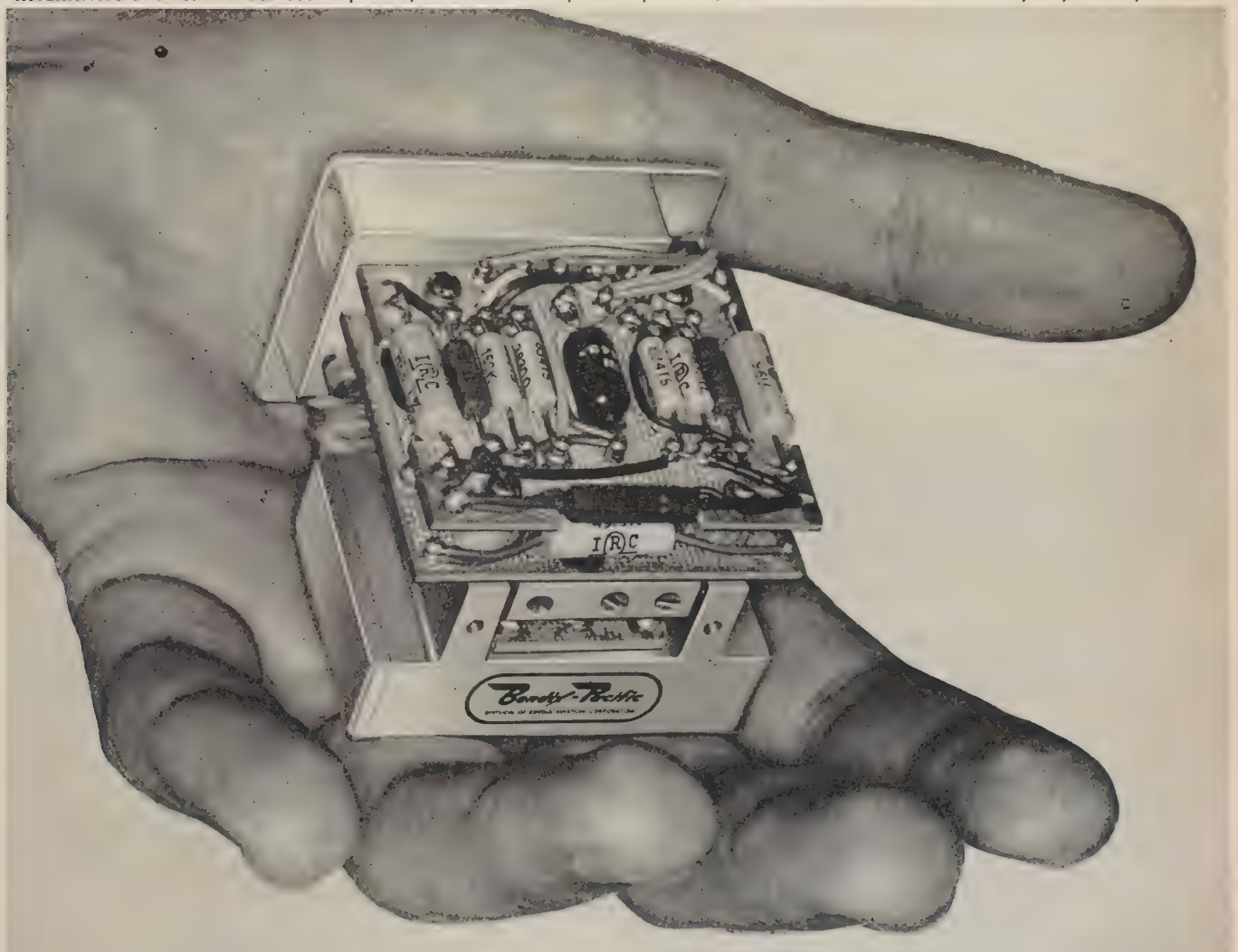

New Subcarrier Oscillator typical of integrated reliability and miniaturization achieved in telemetry equipment by Bendix-Pacific Division of Bendix Aviation Corp., North Hollywood, Cal.

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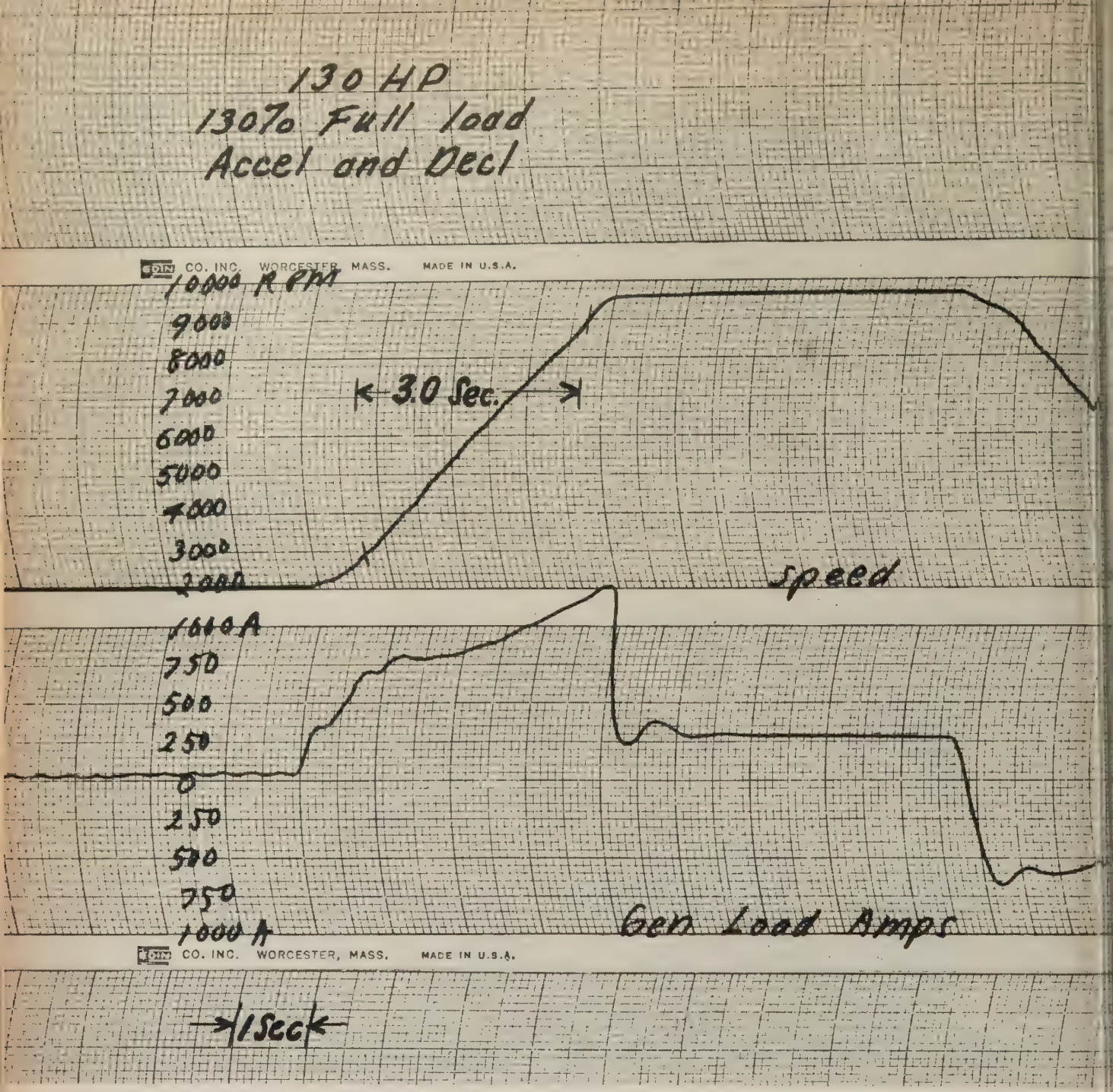


2000 RPM/second at 130% full load..

This is the performance that the Westinghouse test stand installation at North American Aviation, Columbus, gives time after time.

Other outstanding performance characteristics of this dual 100/200 hp test installation are:

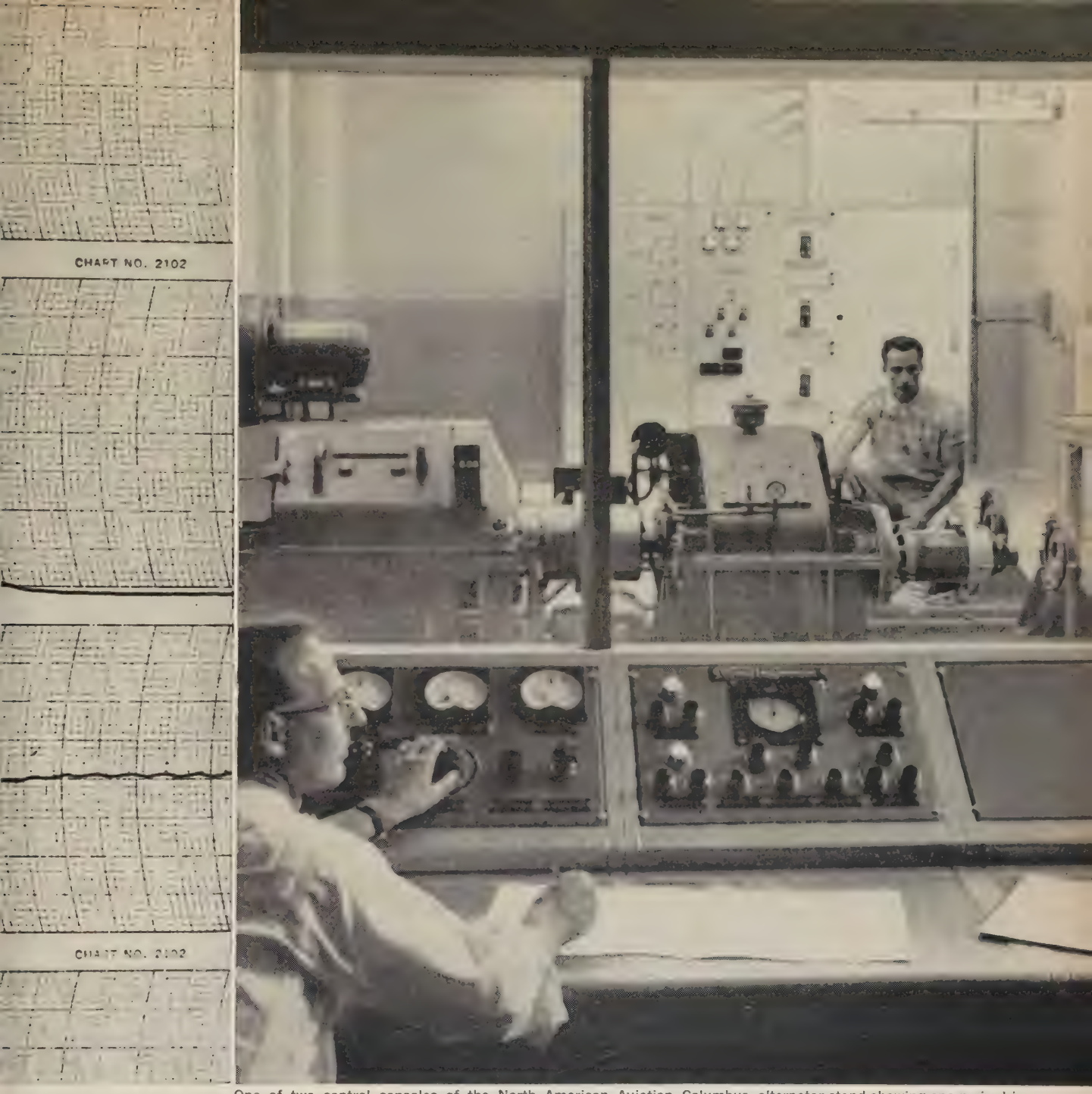
Speed adjustments: from 100 to 11,000 rpm
Speed deviation: 100% load change—not over 1%
200% load application—not over 2%
Recovery time: 200% load application — not over two seconds
Drift: ± 0.25% in eight hours
For overload testing, 150/300 hp is available for five minutes, 200/400 hp for five seconds.

Outstanding features include:

Two output gear boxes each provide 100 hp for thei respective AND pads (dual or single mount).

Twin-drive systems operate independently, or the can be combined for 200 hp delivery from the gea box at either end.

For testing alternators or for complete aircraft/missil electrical systems, Westinghouse test stands permi accurate simulation and evaluation of voltage regula tion, transient response, overload capacity, paralleling operations and shock loading.



One of two control consoles of the North American Aviation, Columbus, alternator stand showing one main drive motor and speed increaser with incoming switchgear and motor control centers in background.

using Westinghouse alternator test stands

Take advantage of this Westinghouse ability to design, develop and install a guaranteed-performance unit for your production development programs for fuel pumps, alternators and complete electrical systems. Contact your Westinghouse sales engineer or write: Westinghouse Electric Corporation, P. O. Box 868, 3 Gateway Center, Pittsburgh 30, Pennsylvania.

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Complete dual end d-c drive showing two of four AND pads with aircraft alternator being prepared for testing. Main motor generator sets and dual test-drive control in background. J-92007

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ing launch produce the most severe vibration. For an instant before actual launch, vibration can exceed 400 g from 50 to 2000 cps. During the boost phase (lasting several seconds), vibration acceleration remains high. It drops off when normal climb flight begin. Vibration from five to 500 cps will exceed 10 g only momentarily.

Rocket noise poses the worst problem

The biggest problem is noise produced as the combustion gases pass through the rocket nozzle at tremendous speeds. On some missiles, 175 db has been measured at the skin directly above the nozzle. Transmission through the skin is slightly attenuated to 140 db. This transmission is air-coupled—mounts would not be helpful, since structural transmission is very low. The energy involved in 40-g, 400-600-cps tests simulates this condition sinusoidally.

Shock conditions occur when a missile leaves its launching surface (see *Diagram*). It is hard to align the force of the boost rocket directly through the CG and in the direction of the climb angle. Missiles usually tend to pitch down slightly during launch. (Little lift is generated by the wing for the first few seconds.)

Drop from rails causes shock pulse

The weight of the missile is overcome by the combined vertical components of the vector forces from engine and boost at the launch angle. The sum of these forces is slightly less than the gross weight, so that the missile will ride along the launch rails. Immediately upon reaching the end of the rails, the missile drops abruptly. This drop causes a shock pulse that is higher in acceleration and rise time and shorter in duration than 150 VD shock tests. The energy content is probably almost the same as in the tests.

Steady-state acceleration is slightly higher than in aircraft, because of the magnitude of boost power. Since missiles are poor lift generators, they reach flying speed only if they have more boost power than an aircraft with an airframe of equal weight. Missile acceleration approaches 7.5 g in the longitudinal direction.—End

Playback on performance

Autonetic's NADAR increases flight training efficiency by making a magnetic-tape recording of everything an airplane's fire control system puts on the radar scope. Minutes after pilot lands, complete record of his performance can be viewed on oscilloscope of NADAR console. Compact, lightweight, airborne tape-recorder (shown above in officer's hand) is fully automatic, has two-hour recording capacity. NADAR is invaluable for pilot and aircrew evaluation and flight testing . . . and remember, military pilots are *always* training. Write for literature.

Autonetics

A DIVISION OF NORTH AMERICAN AVIATION, INC., DOWNEY, CALIFORNIA

Why You Get More Stable Reference Junction Compensation

with an AUTOREF

You get less *total* reference temperature variation in an "AutoRef" because *all* system variables are held to an absolute minimum. Temperature stability, for example, is ± 1/5°F. And the thermocouple wire in all "AutoRef" systems is specially selected from our *own wire mill* to surpass I.S.A. premium grade accuracy. Total "AutoRef" system accuracy is further insured by proper distribution of individual thermocouple junctions, balanced electrical heat input and heat transfer, and sensitive primary control elements. This system accuracy is held to ± 1°F. over ambient temperatures of 75°F., ± 25°F. Such total system accuracy makes the "AutoRef" ideal for measuring temperatures together with other DC signals as on multipoint recorders and other data reduction systems. Minimum No. of points, 12—no maximum.

Write for Bulletin 81-A

Thermo Electric CO., INC.
SADDLE BROOK, NEW JERSEY

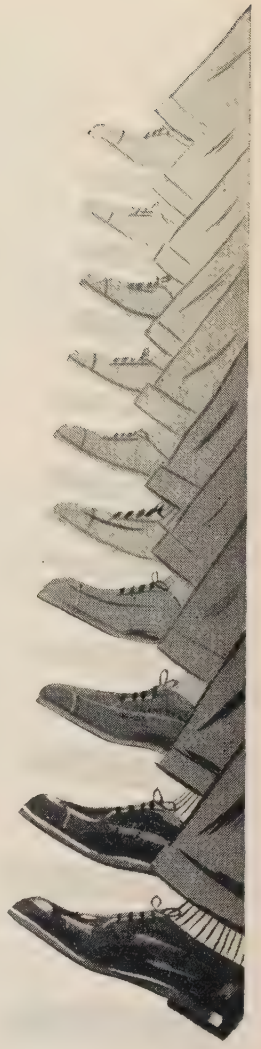
In Canada:
THERMO ELECTRIC (Canada) LTD.
Brampton, Ont.

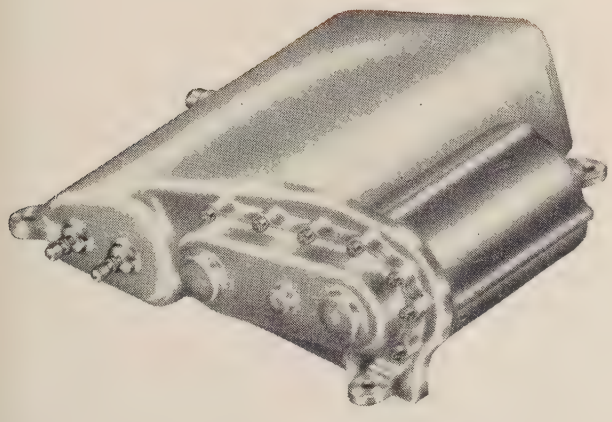
Write in No. 129 on Reader Service Card at start of Product Preview Section

Stratopower

can't afford to stay in step- We have to stay ahead...

years ahead in hydraulic development





STRATOPOWER keeps years ahead in hydraulic development by advanced theorizing, advanced research and testing ..and with the most advanced precision production facilities n the world. Here, for example, is a STRATOPOWER Hydraulic Package being built for a new missile project ... alling for "years ahead" hydraulic technology.

STRATOPOWER Hydraulic Packages and Systems are erfect examples of being "made for each other." They contain everything you need, including specified performance. eservoirs, accumulators, valves, pumps, motors and even lumbing, are all mated into a smoothly functioning unit. The heart of these Packages and Systems is the constant variable displacement STRATOPOWER Hydraulic Pump. Models are available to operate dependably up to 450° F., and at exceptionally high speeds.

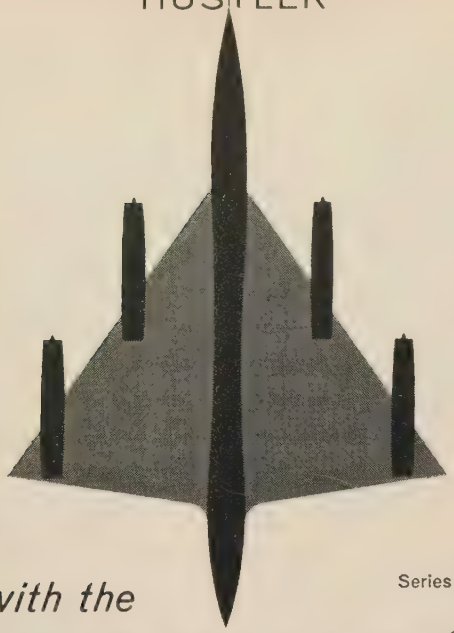
The advanced designs of STRATOPOWER Hydraulic Pumps are made practical by precision manufacturing that makes watchmakers' standards seem clumsy by comparison. 50 millionths of an inch are tolerances found in production models. Specify STRATOPOWER Pumps, Motors, Packages or Systems, and you, yourself, take a giant step ahead of the competition.

WRITE TODAY: *See how your hydraulic power application is best fulfilled by STRATOPOWER Hydraulic Pumps, Packages and Systems . . . it's a step in the right direction!*

WATERTOWN DIVISION
THE NEW YORK AIR BRAKE COMPANY
STARBUCK AVENUE • WATERTOWN • N. Y.

Write in No. 130 on Reader Service Card at start of Product Preview Section

HF Radio Communications to Match
the Performance of the
HUSTLER



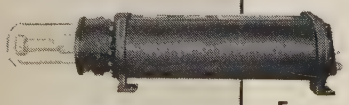
with the Series 3300

UNIVAC®

AUTOMATIC ANTENNA COUPLER

The Univac Automatic Antenna Coupler Series 3300 was designed to meet the most rigorous requirements of long-range, supersonic flight. Originally developed for the Hughes AN/URC 15 air-to-ground communication system, it has been adopted by Hughes Aircraft Co. for Convair's B-58 "Hustler".

The 3300 was created by the same engineering staff which produced the first high altitude automatic antenna coupler . . . it is the product of an extensive research program backed by six years of experience in the engineering, manufacture and field support of over 5,000 automatic antenna couplers.



TUNER Assembly

CONTROL Unit

Frequency Range— 2-36 Megacycles
Tune time—3 seconds average
VSWR—1.7 to 1
RF power-handling capability 1350 Watts
Temp. range—65° F to 256° F
Altitude—Full power up to 75,000 feet
Weight—Tuner assembly 28 lbs. Control Unit 10 lbs.

Designed to operate with memory device and to coarse tune in one second.

Manufactured by Remington Rand Univac—the company with more experience in building antenna couplers for jet aircraft than any other in the world.

For further information and illustrated literature, address:

MANAGER, Engineering Sales
Remington Rand Univac
Division of Sperry Rand Corporation
UNIVAC PARK, ST. PAUL 16, MINNESOTA

Write in No. 131 on Reader Service Card

electronics scanner

RELIABILITY PROGRAM run by Collins Radio on its ARC-58 HF single-sideband transceiver led to more than 580 recommendations for design changes. According to R. L. Vander Hamm, Collins' reliability group head, feedback from the field showed the ARC-58 had a mean time between failures of 167 hours.

NINE KEY POINTS are covered by Collins' reliability programs:

- part and material application—17 applications engineers are available at Collins to advise designers on the use of components and materials in equipment;
- qualification testing of parts and materials—all non-standard parts undergo complete electric, mechanical and environmental tests;
- vendor approval—parts are bought from vendors formally approved through the test program;
- part and material failure analysis—failures during any parts of the test program and in field use are studied to find out their causes;
- module equipment and thermal analysis—a detailed study is made of each module for various air flow rates to determine part surface temperatures, and similar tests are run on complete equipment with the modules installed;
- environmental tests (humidity, vibration, and temperature-altitude);
- part and material reliability analysis—detailed study by reliability engineers of each part and material in relation to its use with a nominal derating factor of two (and sometimes as much as four or five) applied to resistors, capacitors, transistors, and diodes;
- mathematical analysis and prediction of inherent reliability—made concurrently with the reliability analysis, with the prediction based on the parts population and on findings from a previous Collins study;
- manufacturing reliability tests—bench tests lasting up to 80 hours to simulate field conditions.

FAILURE RATE per 1000 hours is 0.8 per cent for electron tubes (other than 0.5 per cent for transistors, according to statistics compiled by the Collins reliability group).

DROP in the use of non-inertial guidance systems is predicted by Aerospace Industries Association in its annual forecast of trends and requirements. "Relative use of space-fixed and precessed-gyro guidance systems may be expected to drop 50 per cent by 1970," says the AIA report. "Doppler-inertial and steller-inertial systems will see marked use by 1965, both in second-generation missiles and space vehicles, by 1970, celestial mechanics systems will be used extensively in space vehicles."

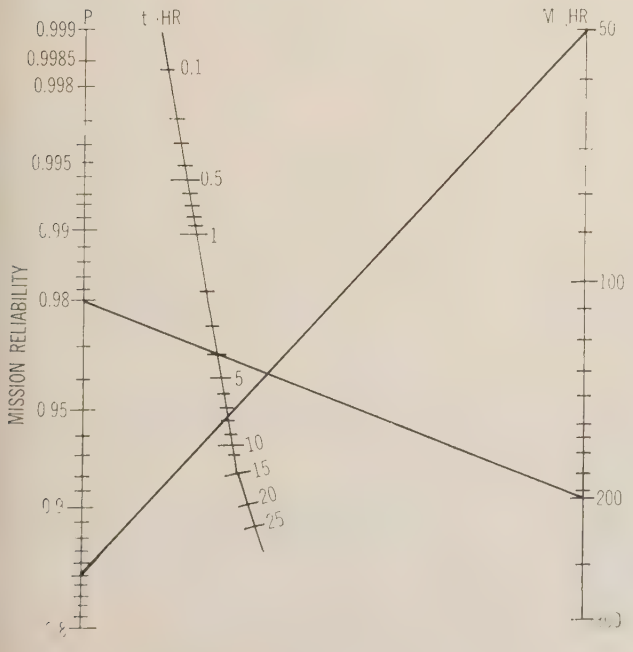
INFRARED GUIDANCE, predicts AIA, will be used increasingly in manned aircraft until 1960, but then will drop markedly. However, its use in missiles and space vehicles will increase significantly in the next decade, according to AIA.

AIA REPORT says "development of nuclear spin gyros *must be completed by 1970*" [S/A italics]. It doesn't make clear why such gyros "must" be developed nor does it venture a guess about how physicists will solve the highly critical research problems standing in the way of workable nuclear spin gyros.

FOR SEVERAL MONTHS, Benson-Lehner has been working on a basic study of energy transfers in systems —and been running into problems posed by the accepted division of physical science into specialized fields. Seeking a uniform theory, B-L hopes to come up with a hypothesis that will provide the key to better under stand and prediction of natural processes, particularly energy transfers. If we knew more about this basis mechanism of systems, we might be able to eliminate steps in systems and set up new and far-reaching requirements for materials.

RELIABILITY NOMOGRAPH prepared by Collins' Radio Reliability Group and reprinted from *Collins Signal,* the company's house organ, shows relation between successful mission, length of mission, and mean time between failure (MTBF) of the electronics equipment. Nomograph is based on the Poisson distribution. For example, equipment with an MTBF of 200 hours would have a success probability of 0.98 on a four-hour mission. If the MTBF is 50 hours and the mission length eight hours, the failure probability would be 0.85. In the nomograph, P is probability of success (no failures); t, the length of time of the mission; and M, the MTBF. The probability of zero failure during time t for an equipment with an MTBF of M is:

$$P_o = \epsilon(1/M).$$



AIR COMPRESSOR and VACUUM PUMP

TO MEET EXTREME AMBIENT REQUIREMENTS

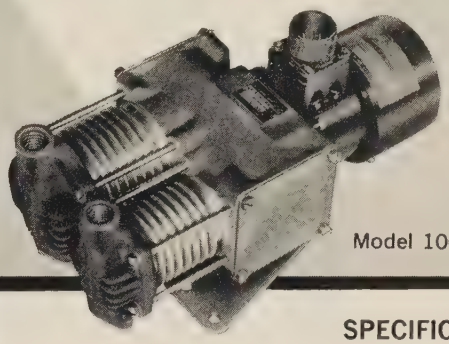
Oil-Free, Self Lubricated — Qualified For 1,000 Hrs. Min. Life

Model 100-797-3 (shown below with specs.) operates efficiently within an ambient temperature range of minus 65°F to plus 200°F... meeting exacting customer and military specifications. This model is representative of a series of similar units designed and developed by Great Lakes to satisfy special requirements.

ATTENTION PROJECT GROUPS & SYSTEMS ENGINEERS!

Great Lakes can save you time and money by incorporating existing units in your design plans at an early stage. You will find that our Engineering, Designing, Testing, and Production Ability will augment your own facilities.

HIGH QUALITY MOTOR-DRIVEN AIR PUMP DESIGNED FOR USE IN AIRBORNE AND GROUND SUPPORT EQUIPMENT



Model 100-797-3

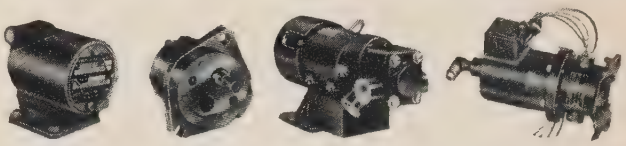
SPECIFICATIONS:

COMPRESSOR CAPACITY . . . .025 PPM at 30 PSI Absolute Outlet with 7 inches Hg. Absolute Inlet Pressure

VACUUM CAPACITY . . . Will reduce 800 Cubic Inch Volume from 29.92 Inches Hg. Absolute to 0.5 Inches Hg. Absolute in 2 minutes with Outlet Discharging to Sea Level.

DUTY CYCLE ..... Continuous

WEIGHT ..... 8.75 Pounds



Absolute Ref. PRESSURE SWITCHES | *4,000 PSI* HYDRAULIC PUMPS | *Motor-Driven* FUEL PUMPS | *Motor-Driven* COOLANT PUMPS

Some of the complete line of products designed and manufactured at Great Lakes.

Write today, for complete information on Great Lakes PNEUMATIC-FUEL-HYDRAULIC Components. An experienced Sales Engineer is available to discuss your requirements.

GREAT LAKES

MANUFACTURING CORPORATION

4223 Monticello Boulevard • Cleveland 21, Ohio

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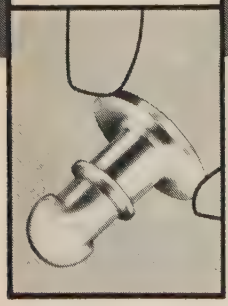
Criteria of Reliability . . .



use LION Quarter-turn FASTENERS

The demands of today's airborne requirements are met by Lion Quarter-turn Fasteners. They are accepted as standard throughout the aircraft industry. They are completely reliable . . . stand up under the most rugged conditions of shear, vibration and tension.

Smooth positive action is assured by the swaged-nose stud on Lion Quarter-turn Fasteners. There are no milled sections, inserts or cross pins; no potential points of failure. No wire spring is required to hold the Fastener in locked position.

One-quarter turn locks the Fastener . . . one-quarter turn opens it. Six head styles and two sizes available. Lion Aviation Fasteners meet MIL-F-5591A (ASG) requirements and are CAA approved.

WRITE TODAY FOR FREE COPY OF
SOUTHCO FASTENER HANDBOOK

Contains complete engineering data on Lion Quarter-turn Fasteners and many other special Fasteners. Write to: SOUTHCO DIVISION, South Chester Corporation, 253 Industrial Highway, Lester, Pa.

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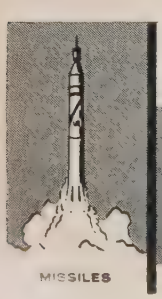
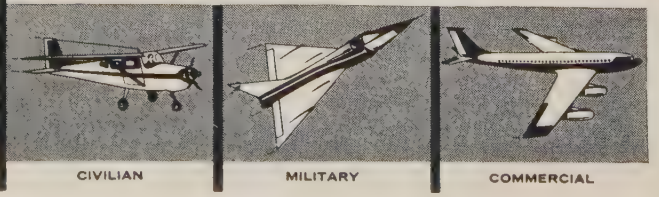




LION *Aviation* FASTENERS

one of the

SOUTHCO LION

FASTENERS

Write in No. 133 on Reader Service Card at start of Product Preview Section

space/aeronautics

CONFIDENTIAL

September 1959
(good until 11/16/59)

Employment Inquiry Form

(NOT an application for employment)

THIS INQUIRY FORM is a service that makes it easier for the interested reader to explore employment opportunities with organizations featuring recruitments advertising **in this issue.**

To use this Form, follow these simple steps:

(1) Tear out this page.

(2) Check off the organization(s) listed below whose employment offers are of interest to you. **Use typewriter or pencil.**

(3) Turn to the back page of this Form and answer the questions on it.

(4) Mail this form (in a stamped envelope) to:

Reader-Service Dept.
SPACE/AERONAUTICS
205 East 42nd St.
New York 17, N.Y.

We will do the rest and promptly forward a copy of your Inquiry Form to each of the organizations you have checked. Depending on their specific personnel requirements, they will get in touch with you at your home.

I am interested in the employment opportunities at:

- ☐ Aeronutronic Systems, Inc.; A Subsid. of Ford Motor Co. 194
- ☐ AiResearch Corp. 134
- ☐ Autonetics Div.; North American Aviation 100, 188, 264, 270
- ☐ Bendix Aviation Corp.; Bendix-Pacific Div. 192
- ☐ Chance Vought Aircraft, Inc. 188
- ☐ Columbus Div.; North American Aviation 326
- ☐ Erco Div.; A C F Industries 186
- ☐ Garrett Corp. 134
- General Electric Co.
  - ☐ Light Military Electronic Dept. 194
  - ☐ Small Aircraft Engines Dept. 186
- ☐ Guided Missiles Range Div.; Pan Am Airways, Inc. 66
- ☐ Int'l. Business Machines Corp. 190
- ☐ Lockheed Aircraft Corp. 140, 141
- ☐ Los Angeles Div.; North American Aviation 190, 252
- ☐ Martin Co.; Denver Div. 75
- ☐ Minneapolis-Honeywell Regulator Co.; Aeronautical Div. 84, 193, 248
- North American Aviation
  - ☐ Autonetics Div. 100, 188, 264, 270
  - ☐ Columbus Div. 326
  - ☐ Los Angeles Div. 190, 252
- ☐ Pan American Airways, Inc.; Guided Missiles Range Div. 66
- ☐ RCA; Govt. Service Personnel 334
- ☐ Raytheon Mfg. Co 318
- ☐ Solar Aircraft Co. 193
- ☐ Texas Co. 189
- ☐ Thiokol Chemical Corp. 297
- ☐ Westinghouse Electric Corp.; Baltimore Div. 191

OTHER (Some organizations' recruitment advertising in this issue may have arrived too late for inclusion in the above list. If you are interested in the employment offers of any of these organizations, just note its name and the page number of its advertisement in this space. Please refer only to ads keyed to this form.): _____

_____

_____

NOTE: If you have an immediate interest in any special employment opportunity advertised in this issue and would like to give more details about your qualifications than can be noted on this Form, we advise you to send your resume directly to the person or department given in the advertisement. We'd appreciate it if you'd mention SPACE/AERONAUTICS in your application.

space/aeronautics

CONFIDENTIAL

September 1959
(good until 11/16/59)

Employment Inquiry Form

Please type or print (with pencil)

(NOT an application for employment)

FIELDS OF INTEREST (in order of importance, note the general fields in which you would like to work—e.g., basic research, dynamics, structures, rocket propulsion, electronic systems, pneumatics, testing, materials, production, ground support, etc.): _____

SPECIALIZED JOB EXPERIENCE (describe the specific technical areas in which you have worked —e.g., flutter, fatigue, fuel systems, circuit miniaturization, servo systems, hydraulic pumps, tool engineering, orbit mechanics, telemetry, data processing, wind tunnel testing, etc.): _____

JOBS AND EDUCATION

List your last 3 employers:

EMPLOYER	CITY & STATE	YEARS EMPLOYED	JOB TITLE OR FUNCTION

List your college and university degrees:

SCHOOL	YEARS ATTENDED	DEGREE

Special Training _____

PERSONAL DATA

AGE ..... U. S. CITIZEN ☐ YES ☐ NO If not, when do you expect to become a citizen? .....

Name: .....

Home Address: .....

Home Telephone: .....

Make sure you have checked the companies you are interested in on the other side of this Form. Then put the Form in a stamped envelope and mail it to **Space/Aeronautics.**

"AT SOME POINT IN HIS CAREER, every engineer critically evaluates himself in terms of his professional growth and progress. If your evaluation indicates that you have developed a depth of appreciation for the major problem areas in large complex electronic systems and the technical competence to contribute to the solution of such problems, you should seriously consider the next step in your professional career and explore the challenging opportunities the System Development Corporation has to offer.

"SDC has assumed major responsibilities for development and sustaining engineering and the implementation of engineering advances in the state of the art associated with the SAGE Air Defense System, the world-wide SAC Control System, and other major system development projects. Therefore, at SDC engineering is system-oriented and requires personnel with broad backgrounds and extensive experience in design, development and system engineering.

"The experience gained through intimate association with all of the elements of these large-scale systems and subsystems they control provides a most unusual opportunity for engineers to grow in technical competence and professional stature.

"I invite you to explore the opportunities offered by SDC at Santa Monica, California and Lodi, New Jersey, by writing or telephoning Mr. R. A. Frank, 2424 Colorado Avenue, Santa Monica, California, EXbrook 3-9411, or Mr. R. L. Obrey, Box 2651, Grand Central Station, New York 17, N.Y., ELdorado 5-2686, regarding our division at Lodi, New Jersey. Your correspondence will receive preferential treatment and its content will be handled in strict confidence."

V. J. Braun

V. J. BRAUN, ASSISTANT DIRECTOR FOR PLANNING, ENGINEERING DIRECTORATE

V. J. BRAUN

SDC

SYSTEM DEVELOPMENT CORPORATION

SANTA MONICA, CALIFORNIA • LODI, NEW JERSEY

Check Employment Inquiry Form on Page 183

ENGINEERS & SCIENTISTS

FOR

Research Programs

IN

Ionospheric Propagation & HF Communications

Our accelerated growth in these fields offers attractive opportunities to join senior engineers and scientists of stature now involved in challenging, advanced projects. Responsible assignments furthering the state-of-the-art in these fields, plus competitive salaries and outstanding growth potential are offered to men who can contribute to the progress of these important programs.

Senior Ionospheric Physicist

Ph.D., preferred plus several years experience in the study of ionospheric phenomena. Should be familiar with present knowledge of upper atmosphere physics and possess an understanding of current programs using rockets and satellites for studies in F-region and beyond. Qualified man with supervisory abilities will have an exceptional opportunity to assume project leadership duties on an HF project already under way involving F-layer propagation studies backed by a substantial experimental program.

Global Communications Specialists

BS degree plus 5 to 10 years' experience embracing theoretical as well as practical knowledge of communications systems design involving F-layer ionospheric propagation techniques. Working knowledge of modern high-power HF transmitters and HF receiving systems.

Senior Electronic Scientist

Advanced degree in E.E. or Physics preferred. Must be familiar with present state-of-the-art in the design of advanced HF receivers and transmitters, and possess working knowledge of modern HF networks employing ferrites and metallic tape cores. Strong theoretical background in modern linear circuit theory desired. Will carry out laboratory development implementation of new HF communication systems.

Staff Electronic Engineers (Radar)

Advanced degree in E.E. preferred. Must be familiar with conventional pulse circuit designs and applications. Technical background should include substantial experience in data process and data recovery systems using both analog and digital techniques. Knowledge of principles and application of modern information theory including correlation techniques helpful. Will be responsible for the design of sub-systems.

Development Engineer

Advanced degree in M.E. or physics preferred. Must be skilled in advanced laboratory techniques in rocket motor development. Strong background in applied thermodynamics, aeroballistics and rocket propulsion desired. This is a new project in planning stage. Opening requires person capable of assuming duties of assistant project manager.

EXCELLENT SALARIES
Commensurate with education & experience
MODERN COMPANY BENEFITS
including educational assistance plan
RELOCATION ASSISTANCE
Ideal living conditions in suburban Washington, D.C.
Expense-paid interviews with selected applicants

Send resume Stating Education & Experience to:
Mr. R. J. REID, Technical Employment Manager

RESEARCH & DEVELOPMENT GROUP
NUCLEAR PRODUCTS—ERCO

DIVISION OF ACF INDUSTRIES INCORPORATED
RIVERDALE, MARYLAND WArfield 7-4444

Check Employment Inquiry Form on Page 183

aircraft gas turbine engineers

HOW MANY YEARS

from you to supervisor?

It shouldn't be a matter of years . . . . but of *ability.*

At General Electric Small Aircraft Engine Department, advancement is a function *only* of ability. Here, most supervisors are young men, and *all* engineers enjoy continual opportunity to demonstrate talent. Both indicate a "young personnel" policy.

Work is a variety of gas turbine problems, plus the decision-making authority to meet them. If interests change, our growth assures the chance to follow new directions.

This growth is steady, secure, and based on the unlimited future for our 4½ to 1—and—better power: weight engines. Presently, it has created new positions at all levels in:

CONTROLS

Responsibility ranges from idea to hardware. You initiate, plan, and execute design and development of extremely compact, reliable systems; troubleshoot control and fuel system problems; direct design audits, failure investigations; serve as senior liaison to Manufacturing and Test. *Gas turbine control or related experience.*

EVALUATIONS

You evaluate an assigned portion of engine mechanical design; establish assembly and test programs necessary to determine and demonstrate engine mechanical reliability; analyze test and assembly results in factory, field and flight, production engine activities. Recommend design changes.

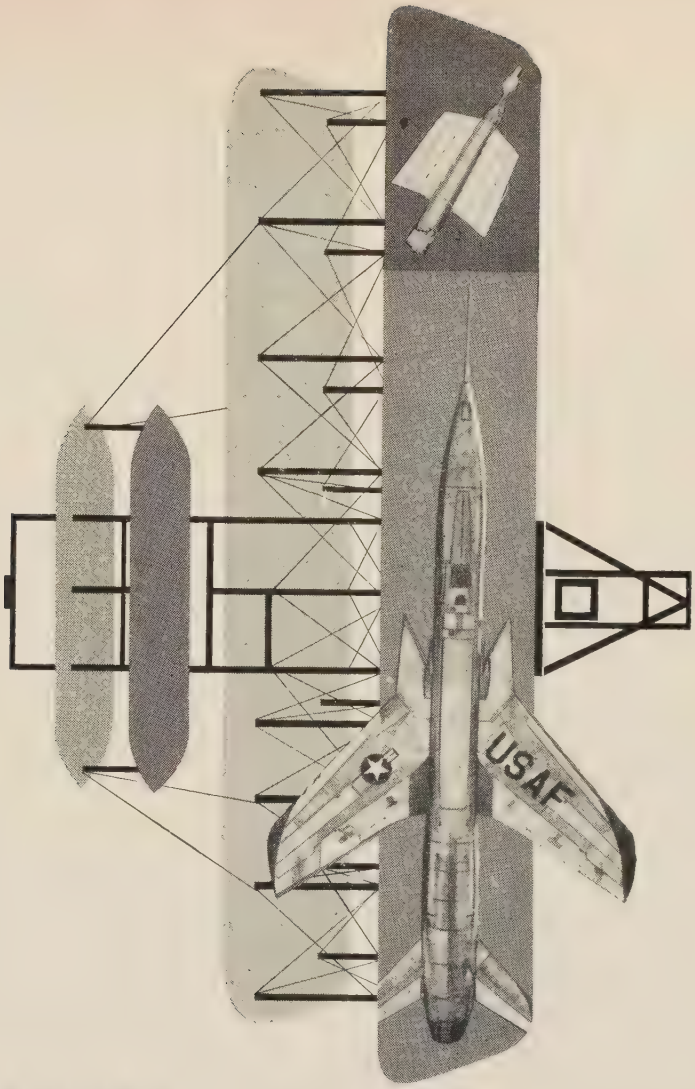
Write in complete confidence to:

MR. RICHARD A. NOLLENBERG
Professional Recruiting and Placement
SMALL AIRCRAFT ENGINE DEPT.
1167 Western Ave., West Lynn, Mass.

GENERAL ELECTRIC

Check Employment Inquiry Form on Page 183

engineers • scientists



IDEAS CLEARLY IMAGINED BECOME REALITIES AT REPUBLIC AVIATION

During the early years of this century the airplane was only the dream of a few dedicated men. Yet in the short span of 5 decades this dream has evolved into such advanced aircraft as Republic's F-105 — the free world's most powerful fighter-bomber — which is capable of flight in the Mach 2 regime.

The same holds true for missiles and space vehicles. Thirty brief years ago they existed in only a few imaginations. Today at Republic the imaginations of many men are working to create the vehicles that will allow man to explore the last frontier — space. Included in this far-ranging research and development effort are plasma propulsion systems, electronic and hydraulic subsystems that will operate efficiently in extreme environments, and the calculation of super-accurate space flight trajectories.

Working across the total technology of flight, Republic engineers and scientists see their ideas become realities because the novel, the unique and the revolutionary in technical thinking are appreciated and encouraged by management. New investigations and new contracts mean you can put your ideas in motion at Republic Aviation.

Immediate Openings in Advanced Areas for Engineers and Scientists at all Levels of Experience:

ELECTRONICS: Inertial Guidance & Navigation • Digital Computer Development • Systems Engineering • Information Theory • Telemetry-SSB Technique • Doppler Radar • Countermeasures • Radome & Antenna Design • Microwave Circuitry & Components • Receiver & Transmitter Design • Airborne Navigational Systems • Jamming & Anti-Jamming • Miniaturization-Transistorization • Ranging Systems • Propagation Studies • Ground Support Equipment • Infrared & Ultra-Violet Techniques

THERMO, AERODYNAMICS: Theoretical Gasdynamics • Hyper-Velocity Studies • Astronautics Precision Trajectories • Air Load and Aeroelasticity • Airplane/Missile Performance • Stability and Controls • Flutter & Vibration • Vehicle Dynamics and System Designs • High Altitude Atmosphere Physics • Re-entry Heat Transfer • Hydromagnetics • Ground Support Equipment

PLASMA PROPULSION: Plasma Physics • Gaseous Electronics • Hypersonics and Shock Phenomena • Hydromagnetics • Physical Chemistry • Combustion and Detonation • Instrumentation • High Power Pulse Electronics

NUCLEAR PROPULSION & RADIATION PHENOMENA: Nuclear Weapons Effects • Radiation Environment in Space • Nuclear Power & Propulsion Applications • Nuclear Radiation Laboratories

Send resume in confidence to:
Mr. George R. Hickman
Engineering Employment Manager, Dept. 6J

REPUBLIC AVIATION
FARMINGDALE, LONG ISLAND, NEW YORK

NEW VOUGHT PROJECTS OFFER CAREER APPEAL TO CREATIVE MEN

exploratory work in wide variety on new metals, methods and weapons

Chance Vought is advancing on many fronts. In *Astronautics* there is development of the 4-stage "Scout" research rocket for NASA. In *Antisubmarine Warfare*, detection and classification studies for the Navy. In *Advanced Weapons*, hypersonic systems are in development. *Electronics* for weapons – and for advanced control systems – are being developed by Vought. The company's Range System Division is managing key missile ranges. These activities have prompted exploratory work in the following areas:

Structures (Supersonic and Hypersonic)

Heat transfer, thermal stress and deflection analysis, and stress analysis using high-speed computers.

Manufacturing R & D

Welding and brazing of super alloys and exotics; advanced forming and cutting studies; prediction of metal fabricability.

Industrial Engineering

Project estimating, work sampling, line load and balance, and packaging and installation of new procedures.

Antisubmarine Warfare

Studies of detection and classification techniques involving Acoustics, Geomagnetism, Geophysics, Electromagnetics, Electrochemistry, Math.

Engineering Planning

Man-hour and budget forecasting, and project planning and scheduling.

Product Design

Automatic escape devices, atmospherically sound cockpits and advanced instrument displays for space pilot, crew.

Flight Test Instrumentation

R & D in new techniques for electronic gathering and reducing of flight test data.

Aerodynamics

Wind tunnel and model work employing Vought's 3,800-mph high-speed wind tunnel and new "high-temperature" laboratory.

Qualified applicants are invited to write:

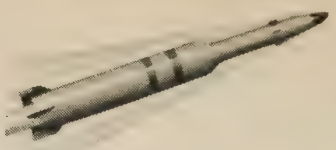
J. W. Larson
Ass't. Chief Engineer, Administrative
Dept. 0-8

AERONAUTICS | ASTRONAUTICS | ELECTRONICS | GEMINI | RANGE SYSTEMS | RESEARCH

CHANCE VOUGHT DALLAS, TEXAS

Check Employment Inquiry Form on Page 183

ELECTRONICS: Over, on and under...



DESIGN ENGINEERS

Are You Interested in

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Radar Armament Controls
Flight Controls
Automatic Checkout Centrals
Digital Computers

If so, you should investigate current opportunities for you at Autonetics in the following:

Electro-mechanical Packaging

Packaging (Preservation & Shipping)

Optical Instrumentation

Cabling and Wiring Harnesses

Digital Computer Devices, Assemblies and Circuitry

Power Supplies

Castings, Precision Instruments & Gearing

Complex Systems Design

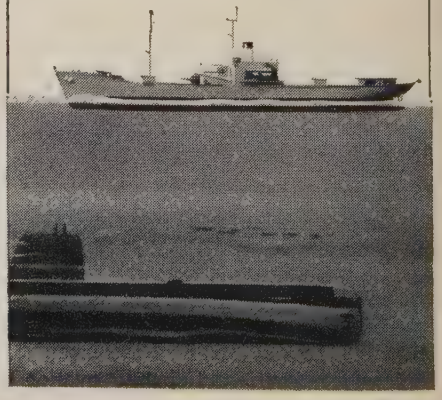
Degree Required.

Tell us about yourself and the work you would like to do.

Send resume to:

Mr. B. D. Benning
Manager, Employment Services, Dept. D-91
9150 East Imperial Highway
Downey, California

Autonetics
A Division of North American Aviation, Inc.



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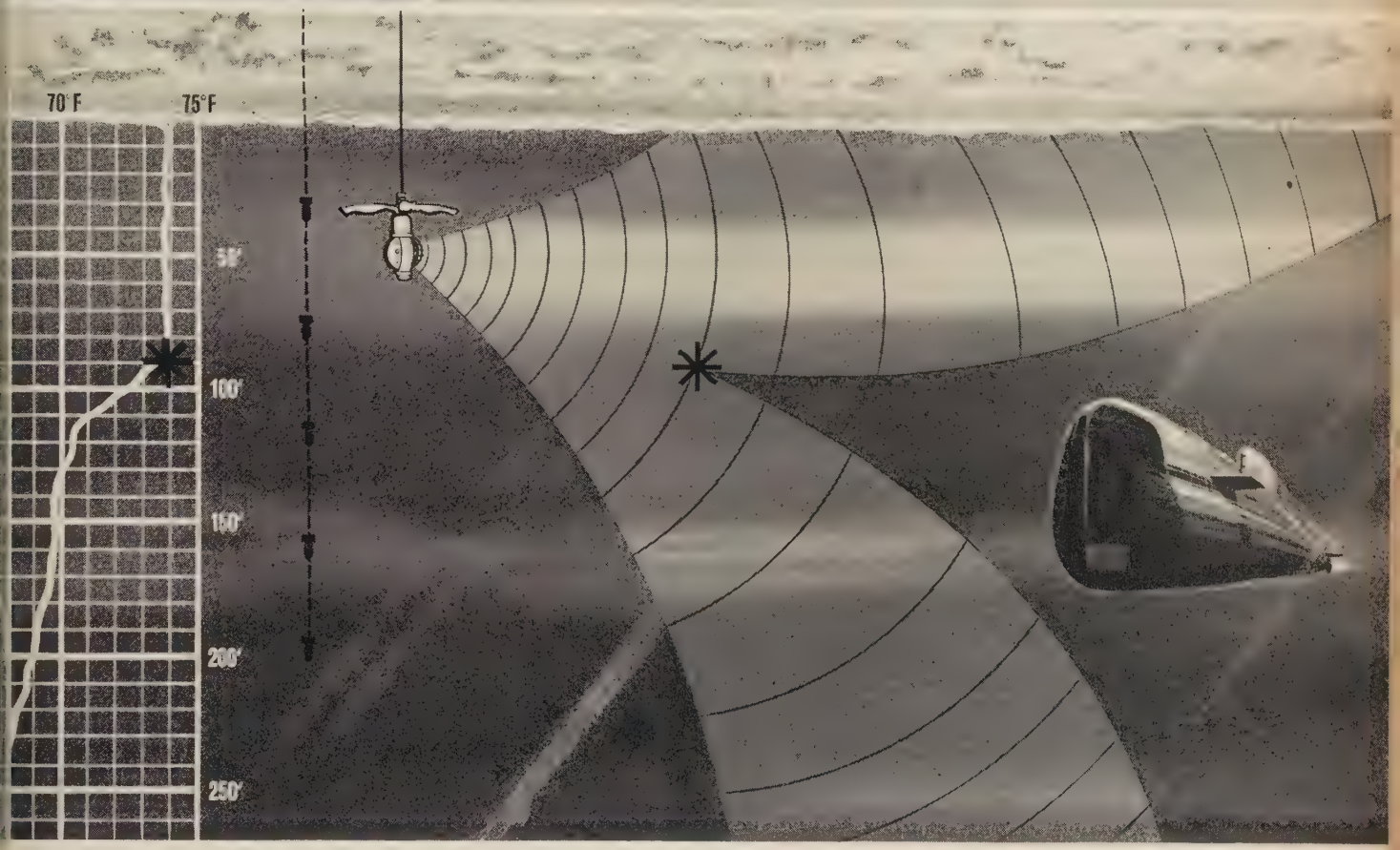
idea:

Submarines can hide within range of helicopter-borne sonar by "riding the thermocline"—a water temperature change that casts shadows in sonar search patterns. Precise temperature-vs.-depth records allow the operator to spot thermoclines and change his search pattern to look into the shadows. Existing gear "worked", but it took too long and could not define the shadow zones very accurately. TI engineers created an automatic recorder, the **bathythermograph,** more accurate than a laboratory thermometer, that gives results instantly where they were needed—in the helicopter. Small as a portable typewriter, it easily fits with the sonar into the space available.

RESULT: Same sonar—fewer missed submarines.



esign, manufacturing and quality engineers—3-10 years experience

high-gain careers for problem-solvers

YOUR SPECIAL TOUCH with unsolved problems buys you a solid future in ny of Texas Instruments major military programs—Antisubmarine Warfare, Heavy Surface Radar, Missile Systems, or Electronic Surveillance. For exam-le, you can try your hand at solving the Navy's clearly stated ASW require-ment: Build *something* that will detect and classify a fast-moving submerged ubmarine at depths of 1500 feet, more than 50 miles from your aircraft.

Your experience in one of the following technologies may find immediate pplication in one of our four major programs:

radar • sonar • infrared • magnetic anomaly detection • passive detectors • servos • navigational systems • special-purpose computers • timers • programmers • microwave • telemetering • data link • optics • video mappers • visual displays • intercom

We require a steady influx of exceptionally-qualified men in these technologies. To learn more about us and how we can fit into your career plan, write for a opy of "We can tell you this much about Apparatus division" to:

J. R. Pinkston *Professional Placement*

APPARATUS DIVISION

TEXAS INSTRUMENTS INCORPORATED

6000 LEMMON AVENUE • DALLAS 9, TEXAS

Check Employment Inquiry Form on Page 183

current career openings

EE's & PHYSICISTS:

radar (ground and airborne), antenna & microwave components, missile guidance, servo-mechanisms, telemetry, digital circuits, infrared design, systems studies, & flight test.

ME's:

antenna, mechanisms, miniaturization, thermodynamics, refrigeration, insulation, packaging, & structures design.

INDUSTRIAL ENGINEERS:

cost estimating, quality control, & quality assurance studies.

MANUFACTURING ENGINEERS:

tooling design & manufacturing planning & supervision. (Degrees in EE or ME.)

write for your copy

Explore new areas at IBM in

MECHANICS

At IBM, engineers are applying the principles of mechanics in radically new ways in order to keep pace with recent scientific advances. One project, for example, involves the design of mechanical and electromechanical devices and servos in the 5-10 millisecond range that will insure minimum noise, vibration and wear. In another project, new concepts of magnetic recording systems are being sought that will enable great quantities of data to be stored in highly miniaturized "memory" devices. Careers are available in such areas as acoustics, applied mathematics, electromechanics, servo mechanisms, systems design and vibration and wear control. For assignments like these, IBM is seeking engineers who can solve the unusual mechanics problems posed by recent technological break-throughs

You will enjoy unusual professional freedom and the support of a wealth of systems knowledge. Comprehensive education programs are available plus the assistance of specialists of many disciplines. Working independently or with a small team, your individual contributions are quickly recognized and rewarded. This is a unique opportunity for a career with a company that has an outstanding growth record.

FOR DETAILS, write, outlining your background and interests, to:

Mr. R. E. Rodgers, Dept. 522 I
IBM Corporation
590 Madison Avenue
New York 22, N. Y.

IBM

INTERNATIONAL BUSINESS MACHINES CORPORATION

Check Employment Inquiry Form on Page 183

TRAINING EQUIPMENT DESIGN

The Los Angeles Division of North American Aviation—Weapon System Contractor for the nation's two most advanced manned weapon systems, the B-70 and F-108—has top-level positions available for

Training Simulator Designers

These highly-qualified engineers will coordinate and monitor the over-all design of training simulator equipment for the most advanced weapon systems projects.

Background preferred: Graduate Electrical Engineer with minimum of four years' experience in design of analog and digital computers with application to simulation requirements.

For more information please write to: Mr. P. J Stevenson, Engineering Personnel, North American Aviation, Inc., Los Angeles 45, California.

THE LOS ANGELES DIVISION OF

NORTH AMERICAN AVIATION, INC.

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ADD A "NEW DIMENSION" TO YOUR CAREER!

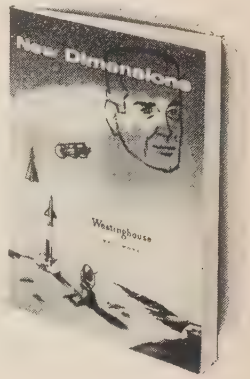
Your career advances by degrees . . . professional degrees. At Westinghouse-Baltimore, you can enjoy stimulating project activities . . . plus the opportunity to advance your career in the Westinghouse Graduate Study Program. In affiliation with The Johns Hopkins University, the University of Maryland, and other leading universities, qualified engineers are assisted in their work toward graduate degrees. This program is described in "New Dimensions" . . . the story of Westinghouse-Baltimore.

Current Career Openings Include:

- Microwave Systems & Components
- Radar Systems
- Network Synthesis
- Analogue and Digital Computer Design
- Airborne Electronic Counter-Measures
- Infrared Systems Development
- Solid-State Devices & Systems
- Test Equipment Design
- Ferret Reconnaissance
- Electronics Instructors
- Communications Circuitry
- Field Engineering
- Technical Writing
- Electronic Packaging
- Experimental Psychologists
- Other positions open for Electrical & Mechanical Engineers and Physicists

Write for "New Dimensions" . . . the informative brochure that takes you behind the scenes at Westinghouse-Baltimore today.

For a confidential interview, send a resume of your education and experience to: Mr. A. M. Johnston, Dept. 959, Westinghouse Electric Corporation, P. O. Box 746, Baltimore 3, Maryland.



Westinghouse

BALTIMORE

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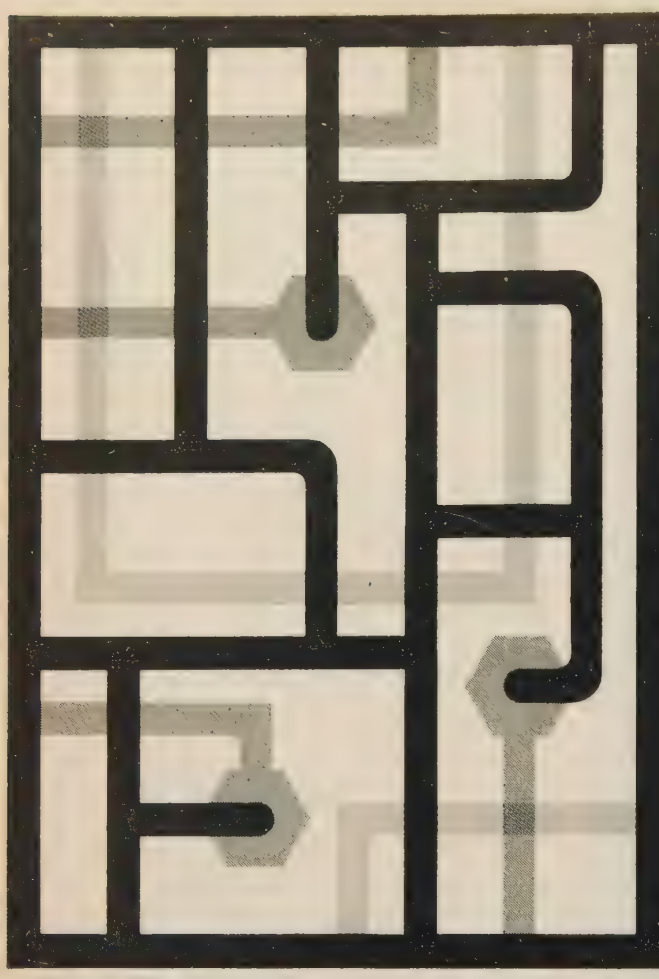


BENDIX-PACIFIC
in Southern California needs

missile/aircraft valve design engineers

Bendix-Pacific Offers You Career Positions in Southern California — WE NEED:

1. Electro-hydraulic high performance servo valve development engineers with 4-6 years experience and a B.S.M.E. degree.
2. General hydraulic valve designers with 2 to 4 years experience and a B.S.M.E. degree.
3. Pneumatic valve and servo designers with 2 to 4 years experience and a B.S.M.E. degree.

PLEASE SEND RESUME TO W. C. WALKER
ENGINEERING EMPLOYMENT MANAGER

Bendix-Pacific
DIVISION OF BENDIX AVIATION CORPORATION

11630 Sherman Way, North Hollywood, California

Other High-Level Engineering Positions Available.

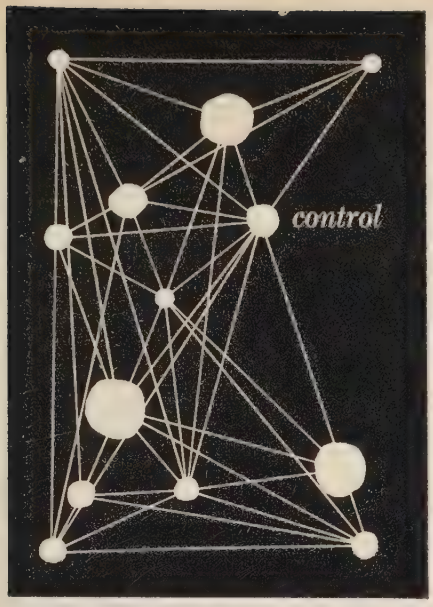
Check Employment Inquiry Form on Page 183

Investigating Employment Opportunities?

Want more information about employment opportunities offered by companies advertising in this issue? Then be sure to give complete data about your job interests, experience and education when filling in the "Employment Inquiry" form.

Although not an application for employment, it provides employment managers with information to evaluate your capabilities—and in turn gives your request immediate consideration.

Check the "Employment Inquiry" form for details.



careers in control of space

PRODUCTION: Develop and establish assembly processes for a wide range of products. Requires background in complex devices such as gyros, accelerometers, flight systems, and a thorough knowledge of production processes.

EVALUATION: Test engineer interested in career in development, qualification, reliability testing. Must be graduate engineer with electronic background.

ADVANCED GYRO DESIGN: Engineers with two and up to twenty years' experience in such areas as precision gyro mechanics, servo techniques, digital data handling, electronics packaging, advanced instrumentation and magnetic components design.

FLIGHT CONTROL SYSTEMS: Analytical, systems, component engineers to design and develop advanced flight reference and guidance systems. Prefer airborne systems or servo experience.

FIELD SERVICE: Monitor airborne system performance in U.S. and overseas. Conduct training, liaison with military BSEE preferred, or graduate engineer with high electronic aptitude.

GROUND SUPPORT: Senior engineers with logical design experience and engineers with experience in ground support or related areas. Outstanding growth opportunity in new division.

If you're interested in a challenging career in advanced automatic controls, write Mr. Bruce D. Wood, Technical Director, Dept. 847A.

MINNEAPOLIS
Honeywell
AERONAUTICAL DIVISION

1433 Stinson Blvd., N.E., Minneapolis 13, Minn.

Fine opportunities also exist in other Honeywell development and manufacturing facilities in the Boston Area, the Philadelphia Area, the Los Angeles Area, Minneapolis, Seattle, St. Petersburg, Chicago and Freeport, Illinois, Denver, and the Washington, D.C. Area. Send resumé to H. D. Eckstrom, Director of Employment, Minneapolis Honeywell, Dept. 847A Minneapolis 8, Minnesota.

Check Employment Inquiry Form on Page 183

Key Positions open for

HIGH LEVEL ENGINEERS

MANAGER, DEVELOPMENT
CHIEF, AVIONICS
CHIEF, ASTRO-AERO SCIENCES
CHIEF, PRELIMINARY DESIGN
CHIEF, STRUCTURES

These five brilliant career openings are the result of the rapid expansion of Solar's Space Age R&D program. Current projects are exceptionally exciting and challenging, including an ARPA project for a completely new anti-missile defense system. Advanced degree preferred plus ten years experience in aircraft, missile and space flight fields. Learn complete details immediately.

SOLAR SPECIFICS

Solar is a medium-size company (2500 people in San Diego) with a successful history since 1927. Solar is making many significant contributions to space-age technology and the special professional status of engineers is fully appreciated and recognized. A new 60,000 sq. ft. engineering building, necessitated by expanding R&D work, will be completed this year on the edge of San Diego Bay. Solar also offers you the chance to live better in sunny San Diego. This famous resort area has the finest year-around climate in America and excellent cultural, educational and recreational facilities. You and your family will enjoy life more at Solar in San Diego.

SEND RESUME

Please send resume of your qualifications at the earliest opportunity to Louis Klein, Dept. E-426, Solar Aircraft Company, 2200 Pacific Highway, San Diego 12, Calif.

SOLAR
AIRCRAFT COMPANY
SAN DIEGO
DES MOINES

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Electronics Engineers:

How To Get Ahead in Radar

Engineers working in Radar today are finding it sometimes takes *more* than an individual's talent and creativity to keep pace with the field.

The element that can make *all the difference* in a man's professional growth—is his company.

Management at Light Military* is aware of this ...and recognizes that LMED's long-term growth depends upon setting the proper environment for creativity... providing advanced projects on which to exercise it... encouraging *and making room for* a man's professional development.

If *you* join Light Military this month, chances are you'll find opportunities to contribute to such systems as:

An automated AEW and control system which—for the first time—will practically eliminate Man from the control loop.

An advanced airborne Bomb Nav. & Forward Surveillance radar system which will utilize high resolution techniques and be equipped with frequency diversity capability.

Or a number of classified programs including Missile Guidance, Surveillance and Fire Control Radars with advanced capabilities.

If you'd like to learn more about how *your* talents can get you ahead in radar faster at LMED, write in confidence to Mr. William Gilmore, Dept. 60-MI.

LMED

*LIGHT MILITARY ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

FRENCH ROAD, UTICA, NEW YORK

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ENGINEERS AND SCIENTISTS

RESEARCH OPPORTUNITIES

Aeronutronic, a new division of Ford Motor Company, has immediate need for qualified people to staff senior positions at its new $22 million Research Center in Newport Beach, Southern California.

The Space Technology Operation offers the highly desirable combination of new facilities and advanced equipment, located in California's finest environment for living and raising a family. Investigate these exceptionally rewarding positions now:

VEHICLE TECHNOLOGY

- Aerodynamic design and testing
- Rocket engine development
- Rocket nozzle and re-entry materials
- High temperature chemical kinetics
- Combustion and detonation theory
- Combustion thermodynamics
- High temperature structural plastics & ceramics
- Advanced structures
- Rocket vehicle systems

MISSILE DEFENSE

- Supersonic aerodynamics
- Aerothermodynamics
- High temperature heat transfer
- Space physics
- Re-entry programs

ASTRO SCIENCES

- Space electronics
- Guidance & control
- Communications
- Instrumentation
- Experimental physics
- Plasma and magneto-hydrodynamics studies

Qualified applicants are invited to send resumes and inquiries to Mr. R. W. Speich, Aeronutronic, Dept. 11, Box 451, Newport Beach, California.

AERONUTRONIC

a Division of Ford Motor Company

Newport Beach

Santa Ana • Maywood, California

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For more detailed information... on Products or Service use this "TIME-SAVER" Card

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New York, N. Y.

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product index to advertising

THIS IS A SPECIAL REFERENCE to the product information given in the advertisements in this issue. It is intended solely to help the reader make the best use of these ads. Therefore the index does not necessarily cover all the products made by each advertiser. Also, cross-listings are not intended to exhaustively describe each product but merely to make sure that each product can be found with reasonable ease by the reader looking for it.

Similar indexes to services and employment opportunities featured in ads follow this index.

Advertisements for which complete proofs were not available to the Editorial Department by the closing date are not necessarily covered by these indexes. (Proofs can be forwarded internally by the Production Department only for advertisements meeting the closing dates.)

For more detailed information on any product or service advertised in this issue or featured in its Product and Data Reviews, use the handy Reader Service Card.

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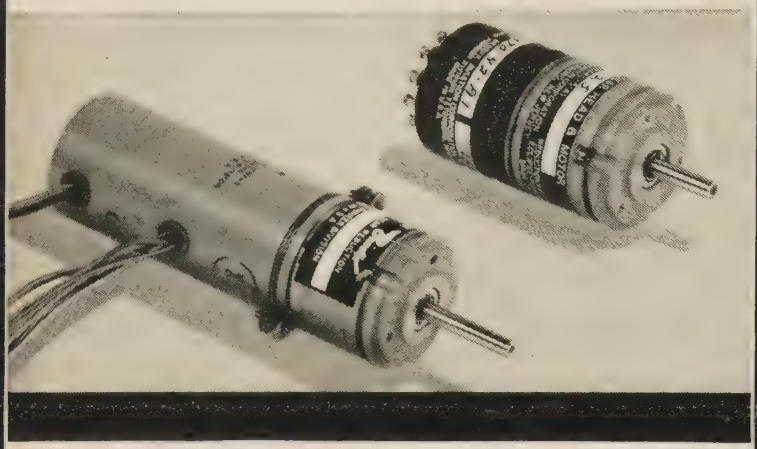
BENDIX GEAR HEAD MOTORS AND MOTOR GENERATORS

. . . tailor-made or standard for any requirement



"Ratios to order" describes the complete Bendix line of gear head motors and motor generators. Long experience in the design and production of these precision devices has taught us how to pack high-operating torque capacities and power into small packages—and into big ones, too, if that's what you need. And we can deliver from our wide standard line at volume-production prices. We've a wide range of frame sizes available or will build special sizes on special order. No matter what the size or ratio required, we can produce it. In fact, units have been delivered *from our standard line* with ratios ranging from 7.22:1 up to 42,471.90:1. Many other "production" models are now under development. DESIGN VARIATIONS, TOO! For example, we can provide units with: backlash of 1/10° *without using anti-backlash devices;* offset output shafts; gear heads to be mounted by internal fasteners or by external clamps; and many other variations.

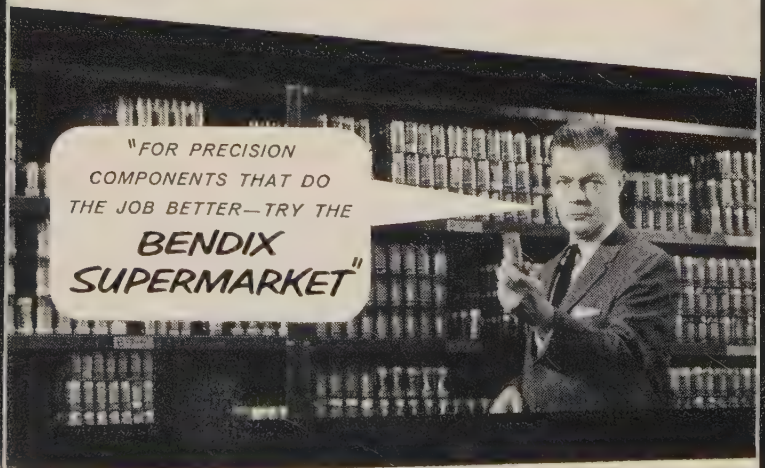
Whatever your requirements in gear head motors and motor generators, our experience and facilities can produce the unit you need. Write for details.

Eclipse-Pioneer Division

Teterboro, N. J.

District Offices: Burbank and San Francisco, Calif.; Seattle, Wash.; Dayton, Ohio; and Washington, D. C. Export Sales & Service: Bendix International Division, 205 E. 42nd St., New York 17, N. Y.

Bendix AVIATION CORPORATION



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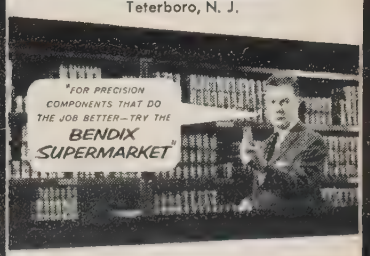

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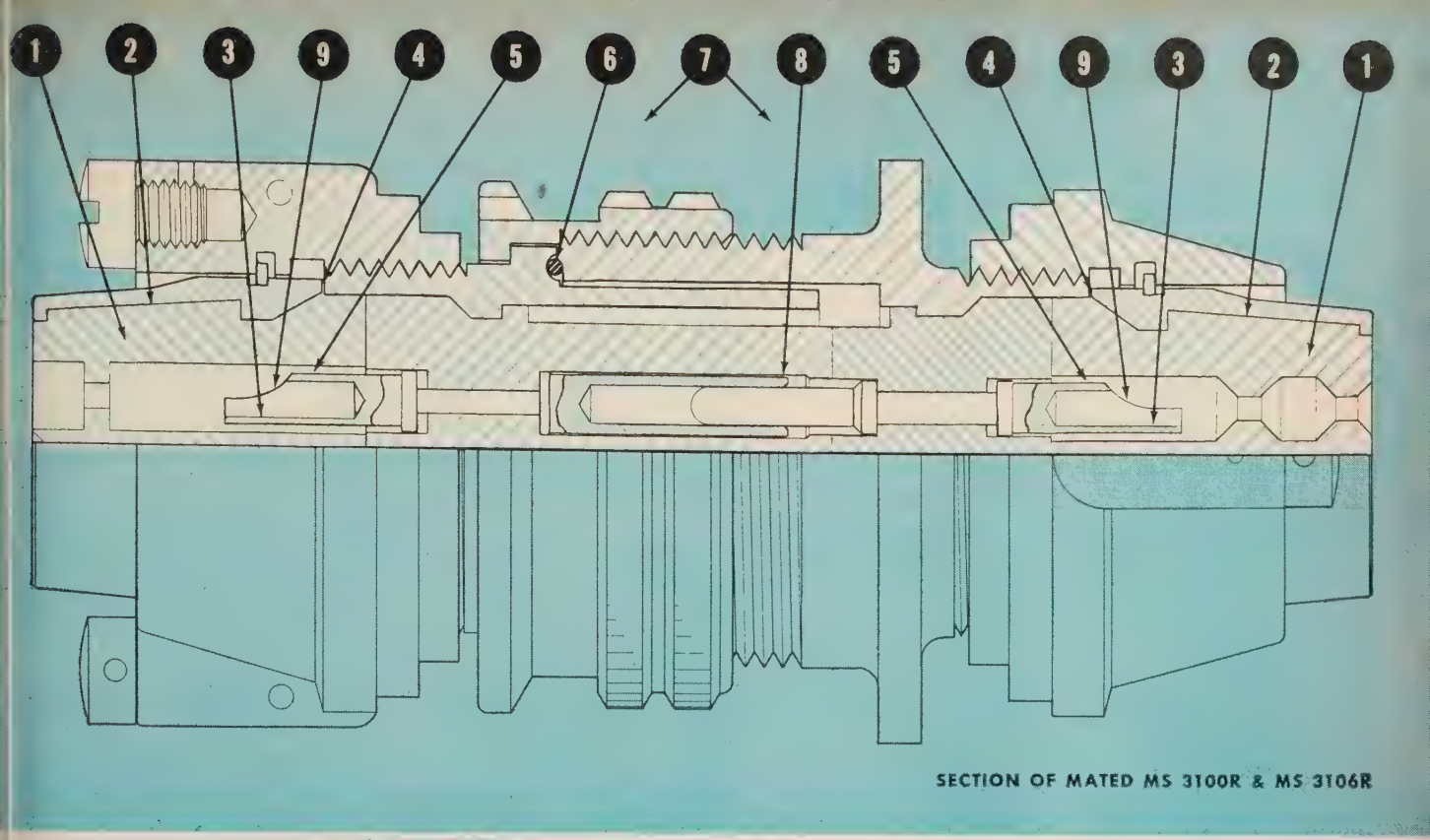


SECTION OF MATED MS 3100R & MS 3106R

STUB E R

Check the PLUS features of the NEW Amphenol "R"!

Stub R is the newest member of AMPHENOL's family of fully approved MIL-C-5015D environmentally resistant connectors. The "R" construction is a recent addition to this Specification and is described as "environment resistant–light weight". Like AMPHENOL's superior Stub E, the Stub R offers plus features above and beyond the minimums established by the Specification. Together, these connectors provide users with a complete selection of the shortest, lightest, finest environmentally resistant AN/MS connectors available to MIL-C-5015D. AMPHENOL Stub R connectors offer the following plus features:

1 **Slippery Grommet Material** A special neoprene material that allows easy slippage over wires. A cost-saving advantage that speeds up assembly.

2 **Unitized Rear Grommet** Grommet, clamp nut, clamp shell and retainer ring form a *single* subassembly, making assembly and disassembly easier and quicker than with any other "E" or "R" connector.

3 **Uniformly Tinned Solder Pockets** Uniform and complete distribution of solder tinning on the inside of the solder pockets, assuring the user of producing the best electrical and mechanical connection.

4 **Metal-to-Metal Bottoming** The unitized rear grommet provides metal-to-metal bottoming to the front shell when the grommet is fully engaged, assuring pre-determined, controlled sealing and minimizing the possibility of compression "set".

5 **Ease of Soldering** Solder pockets are exposed for easy wiring and soldering, providing fast, low cost and high quality assembly.

6 **"O" Ring** The Stub R incorporates an "O" ring on the shoulder of the MS 3106 plug for additional sealing protection.

7 **Shorter Length, Lighter Weight** Both Stub E and Stub R are the shortest and lightest types available, allowing for more compact equipment that saves money where weight = money, as in aircraft.

8 **Closed Entry Socket Contacts** Resistant to test prod damage, female contacts are machined of a copper alloy and provided with a closed entry.

9 **Positioned Contact Pockets** All solder pockets face in the same direction, accelerating wiring and substantially reducing assembly costs.

MS 3100 E&R | MS 3101 E&R | MS 3102 E&R | MS 3106 E&R

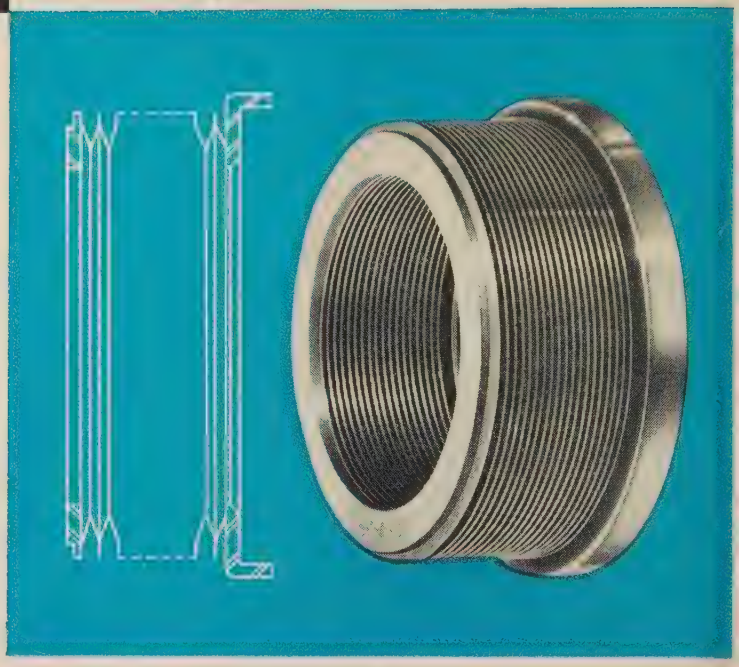
AMPHENOL CONNECTOR DIVISION *1830 S. 54th Ave., Chicago 50, Illinois*

Amphenol-Borg Electronics Corporation

Write in No. 136 on Reader Service Card at start of Product Preview Section

C/R DESIGN NOTES

How C/R's New Metal Bellows Seal Meets Seemingly Impossible Operating Conditions



Operating Ranges

Temperature	−400° to 1000° F.
Pressure	500 psi
R.P.M.	80,000 plus

These known operating ranges indicate the function of this seal. It is designed for applications where temperatures and mediums to be sealed forbid the use of any organic materials. Typically, these applications include fuel pumps, compressor power units and turbine starters characteristic in rockets and missiles. Other applications include mechanisms which are exposed to a high level of radioactivity.

Design Advantages

The C/R metal bellows seal consists of a metal bellows — a welded homogeneous unit which is secured at one end — and a carrier ring in which the sealing face is mounted. The seal does not contact the shaft. It is stationary, and the only rubbing surfaces are the sealing face and mating ring. These surfaces are precision lapped to provide a positive seal with minimum friction. At any given pressure, the seal can be designed to maintain proper and constantly effective face loads. It orients immediately to run-out and will resist any torques it is subjected to in operation. The design has high end-play tolerance: Chicago Rawhide engineers have deflected a bellows .100 in. for three million cycles at 1750 cpm and at a temperature of 500° F. with no adverse effects.

A further advantage is relatively light weight and compactness. The C/R metal bellows seal can be designed for minimum axial and radial space. Axially, complete seals can be produced within a ¼ in. cross-section. Radially, dimensions are comparable with conventional end face seals.

The C/R metal bellows seal can also be designed with an extremely low coefficient of expansion. The importance of this factor becomes apparent with the fact that in many applications the operating temperature may change hundreds of degrees in a very few seconds.

Mediums To Be Sealed

Virtually any known liquid or gas may be positively sealed with this design, depending upon duration or service life. From a practical viewpoint, the C/R metal bellows seal is the best design for the sealing of cryogenic and high-energy fuels such as LOX, hydrogen peroxide, fluorine and other missile and rocket propellants.

Where possible, lubrication of the two sealing faces is desirable to prolong service life. However, the medium being sealed commonly acts as the lubricant and may be merely hot gas.

Materials

Sealing faces and mating rings for the C/R metal bellows seal are available in a variety of materials including carbons, carbides, ceramics and various alloyed metals for both high temperature and corrosion resistance. The bellows can be furnished in any of several metals and alloys such as stainless steel, Monel, Inconel X, Ni-Span C and other special alloy steels.

Consult C/R Engineers

Each application for the C/R metal bellows seal is essentially a custom-design and an intimate knowledge of all conditions to be encountered must be known by Chicago Rawhide engineers to produce the correct combination of properties in the seal. Then, whether you require five, fifty or five thousand seals, Chicago Rawhide will design and produce the correct seal to solve your problem.

Helpful Design Data:

We will gladly furnish you with a design guide and space envelope data concerning the C/R Metal Bellows Seal. Just write for Bulletin MBS-1 on your company letterhead.

CHICAGO RAWHIDE MANUFACTURING COMPANY

1293 Elston Avenue • Chicago 22, Illinois

Offices in 55 principal cities

In Canada: Chicago Rawhide Mfg. Co. of Canada, Ltd., Brantford, Ontario

Export Sales: Geon International Corp., Great Neck, New York

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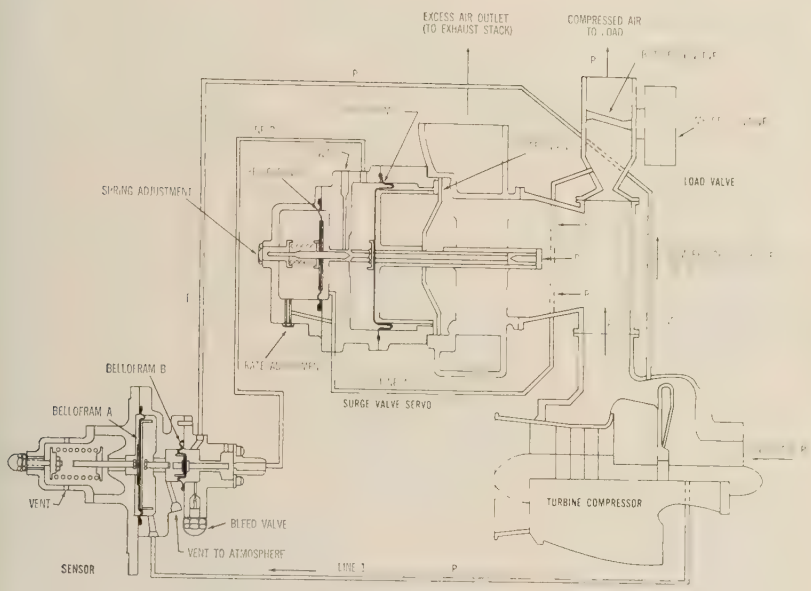
equipment briefs



DIAPHRAGM SURGE CONTROL

A UNIQUE control system has been developed by Continental Aviation & Engineering Corp., 1470 Algonquin Ave., Detroit, Mich., to prevent damage by normal and shock pressure surge in some of its gas turbine compressors. Under normal operating conditions, the turbines compress about 30 per cent more air than is required. During engine acceleration and at "no load" speed, this excess air must be bled or bypassed from the turbine housing to prevent surge. The amount of bypassed air is regulated by a surge valve servo and a sensor, both of which use Bellofram* seals.

Atmospheric and compressor inlet air pressure are fed into the housing where they are balanced against the compressor discharge air pressure. The sensor automatically integrates these signal pressures and transmits an operating signal to the surge valve servo.

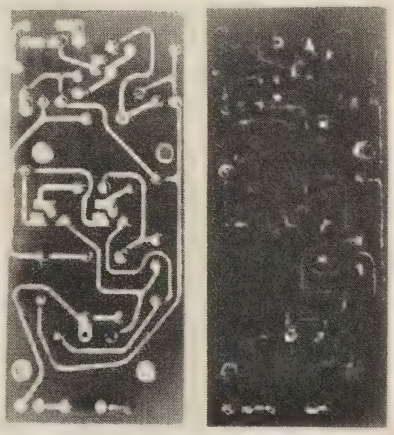
For example, when the load valve is turned to "open", the sensor detects an increase in air flow through the engine. As this flow increases, there is a reduction of both static pressure (P_1, via ilne 4) and compressor discharge pressure (P_2, via line 2), which closes valve A. Atmospheric line 3 is also closed, and the discharge pressure P_2, flowing through the hollow shaft of the servo, can exert a force on the diaphragm seal. This force moves the poppet valve and closes the stack outlet.

Both diaphragms in the sensor and the smaller one in the servo valve have extremely thin sidewalls. On one side, the wall is supported by a Dacron overlay that has high tensile strength and excellent temperature stability. The result is a highly flexible, non-porous membrane. The other side of the wall is compounded from a fluorinated silicone rubber that resists both high and low temperatures.

* Registered trademark, Bellofram Corp.

BLACK-LIGHT INSPECTION

MANY otherwise invisible contaminants are easily detected under black light with a high-intensity portable Blak-Ray lamp developed by Black Light Eastern Corp., 201-04, Northern Blvd., Bayside 61, N. Y. Potential applications of the lamp include the visual inspection of printed circuit wiring, liquid oxygen (LOX) plumbing, and miniature precision mechanical assemblies.



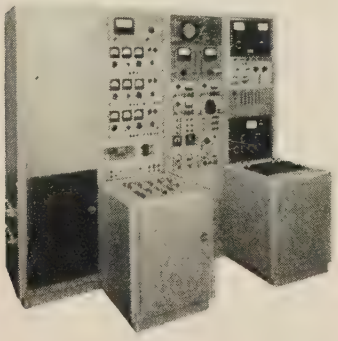
The main contaminant of printed circuit boards and electronic components is residual solder flux. Traces left after cleaning are invisible to the naked eye and can only be detected with the aid of a Blak-Ray lamp, says the company. The solder flux is naturally fluorescent and glows a bright off-white color under black light. The *Photo* shows an apparently clean circuit board under white light (left) and the same board with the residual flux fluorescing under black light (right).

In LOX, particles of hydrocarbon fluoresce brilliantly under Blak-Ray lamp. It is easy to spot contaminated parts. Many Blak-Ray lamps are reported to be in use at Cape Canaveral and other missile bases for this purpose.

Miniaturized gyros and relays are extremely susceptible to dust contamination. Even though the units are assembled in dust-free rooms and under high-powered microscopes, it is difficult to make sure that not even the slightest trace of dust or lint is left. Often it is impossible to see lint particles against the background of shiny metallic surfaces even under a microscope. But under black light, most lints stand out as brilliant blue-white beacons against the violet reflection of the metallic surface background. Write in No. 56 on Reader Service Card for more information.

GROUND SUPPORT EQUIPMENT

A Proven Kearfott Capability – Kearfott's prominence in the design and production of ground support equipment is a result of 15 years' experience in producing precision servo systems, computers, gyro reference systems and inertial guidance equipment. Kearfott test equipment is designed on modular principles which increase flexibility and economy and eliminate the obsolescence factor since modules can be readily modified or replaced. Modules are designed to be compatible with one another, thus providing test capabilities for a wide variety of applications.



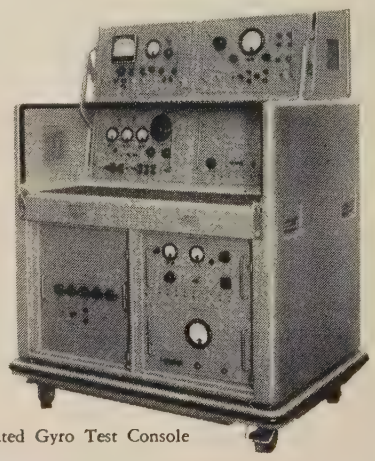
Inertial Guidance System Test Console

IN-PLANT TEST EQUIPMENT: Rack-mounted modules comprise the necessary metering circuits, signal generators and power supplies, switching circuits and junction boxes to perform the following tests on inertial reference systems:

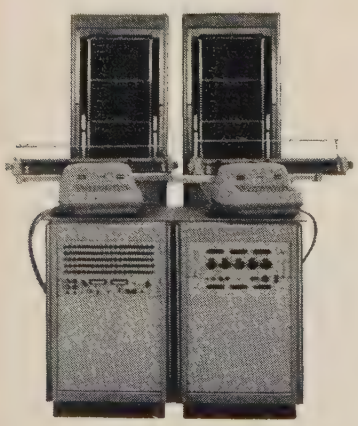
Voltage and phase • Current • Heating cycle checks • Verticality of platform in ground erection mode • First order erection time in ground erection mode • Measurements of platform roll and pitch output angles in ground erection mode • Measurements of free drift of platform in azimuth in ground erection mode • Measurement of azimuth gyro torquer scale factor in ground erection mode

FIELD-TYPE TEST EQUIPMENT: Modularized, self-contained unit that provides all power and signal voltages to operate, test or trouble-shoot a gyro. All inputs to and outputs from the gyro are accessible at convenient jacks where connections to measuring equipment can be made, thereby enabling operator to evaluate gyro performance completely. Modules are slide-mounted for ready access if repair, modification or product improvement replacement are required. This portable equipment performs these basic tests:

Insulation resistance • Warm-up time • Torquer scale factor measurement Gyro transfer function • Free drift • Gimbal offset drift • Continuity Signal Generator Null • Phasing • Gyro drift • Fixed torque restraint



Floated Gyro Test Console



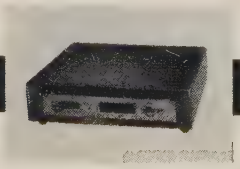
Scanalog 200-Scan
Alarm Logging System

GENERAL PURPOSE DATA PROCESSING: This data handling system provides a reliable, precise means of monitoring, logging and performing an alarm function of up to 200 separate temperature, pressure, liquid level or flow transmitters. Manual controls are provided for scanning rates, automatic or manual logging, data input relating to operator, time, day, run number and type of run. 200 numbered lights, corresponding to specific points being maintained, provide a visual "off normal" display for operator's warning. This system has growth built in and can be expanded in capacity to 1024 points and in scanning rate to 2000 points per second.

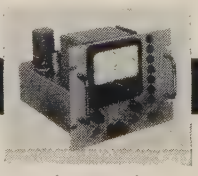
Write for complete information on Kearfott's ground support equipment.

Engineers: Kearfott offers challenging opportunities in advanced component and system development.

VTVM-PSVM



High-Speed
Precise Angle
Indicator Module



Automatic
Ohmmeter
Module

Kearfott | A GENERAL PRECISION COMPANY

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A subsidiary of General Precision Equipment Corporation
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West Coast Office: 253 N. Vinedo Avenue, Pasadena, Calif.

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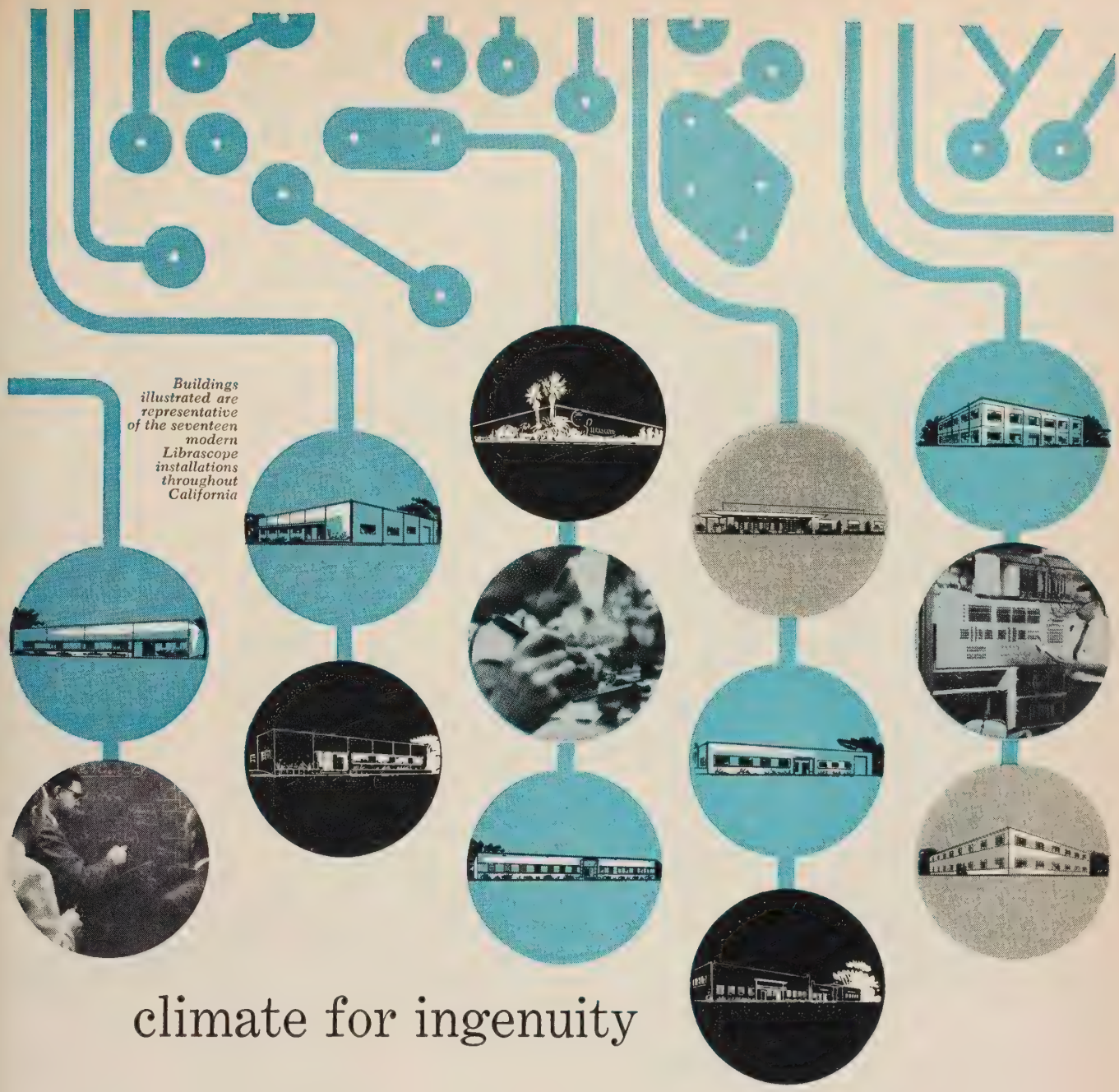

Buildings illustrated are representative of the seventeen modern Librascope installations throughout California

climate for ingenuity

'Facilities' is more than a masonry-and-steel term at Librascope...it represents an overall regard for the tools of creative engineering—climate, time, equipment.

'Facilities' also mean the coordinated efforts of skilled people working in seventeen modern Librascope installations throughout California.

For more than 20 years, Librascope has been recognized as a leader in the development of controls, computers and components...answering military and commercial requirements with timeliness and ingenuity.

Today, Librascope's *'facilities'* continue to grow at a rapid pace...providing an ever-expanding climate for ingenuity.

LI 9-19

For information on career opportunities, write Glen Seltzer, Employment Manager.

For details on how Librascope can anticipate and solve your computer and control problems, you are invited to write:

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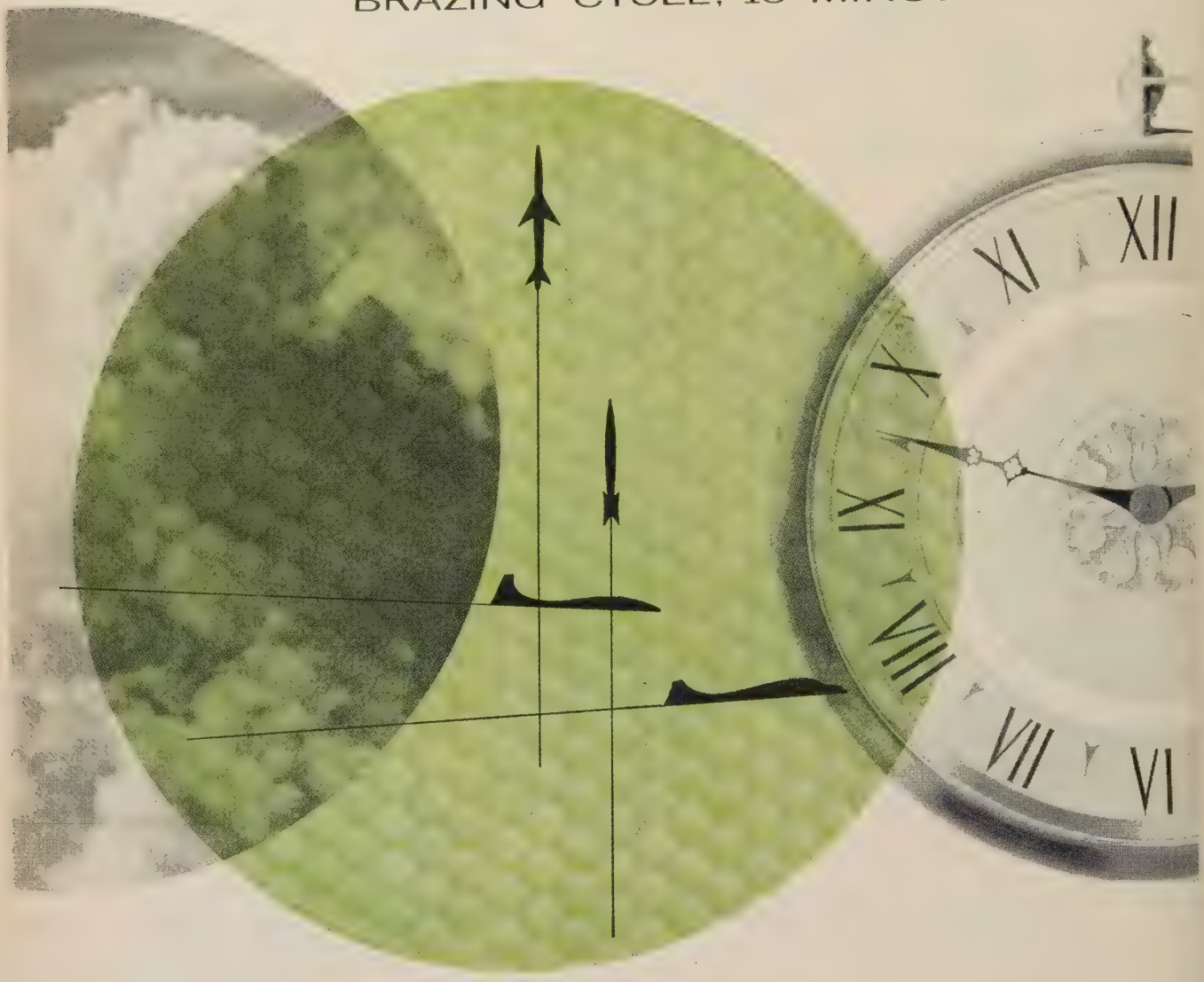
INSTANT HONEYCOMB

BRAZING CYCLE, 15 MINUTES



Using the molten salt process, Temco's Missiles and Aircraft Division produced a precise control surface for the Hughes GAR-9 missile . . in just eleven weeks from go-ahead on design to completion of the first component. Significant breakthroughs: a 50% reduction in weight; retention of maximum strength; greater economy; a high production rate. "Instant honeycomb" is an example of Temco's quick reaction capability . . an inherent capability based on intensive research and development and concentrated effort on the part of Development Project Management.

Many excellent engineering and scientific positions are now open in this and other Temco programs. We invite your inquiry.

TEMCO MISSILES & AIRCRAFT

A division of **TEMCO AIRCRAFT CORPORATION • DALLAS 22, TEXAS**

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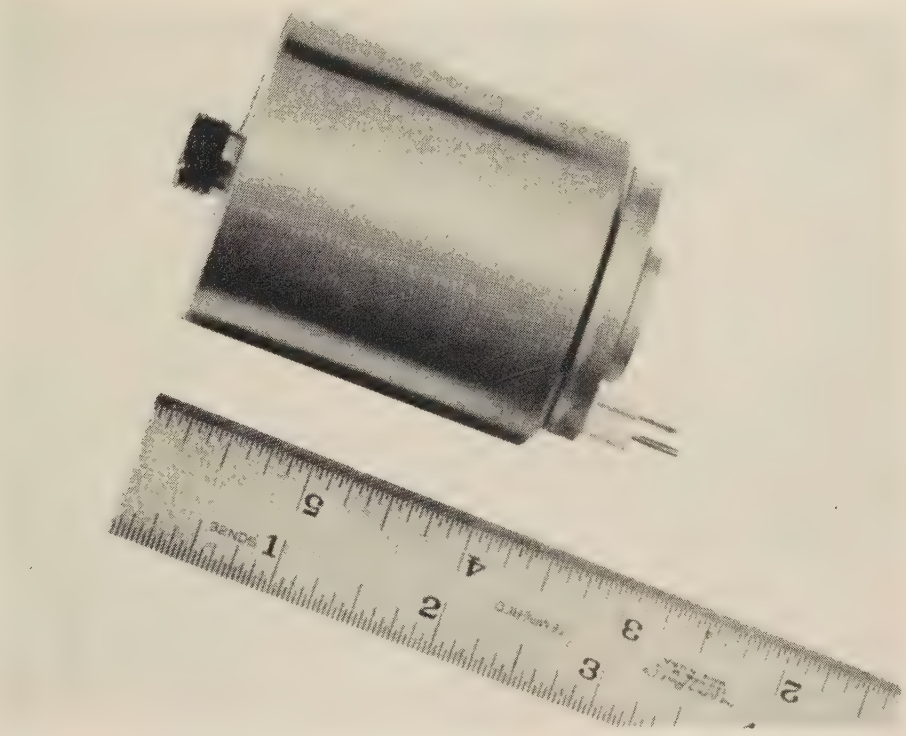
space aeronautics **product of the month**



Feature Product Award

SEPTEMBER 1959

SOLENOID
works continuously at 1000° F

Rocker Solenoid Co., 140 N. Marine Ave., Wilmington, Calif., has designed a new solenoid for aerospace applications in which engine or re-entry temperatures rule out more conventional units. Continuous ratings for extremely high temperatures have been achieved through a new method of coil-and-bobbin manufacture, the company claims.

Special solenoids for operation at 1000 deg F can be built to customer specs. Test units have been run successfully at even higher temperatures. Previous high temperature solenoids, Rocker states, were rated at 600 deg F, though some had been operated to 800 deg F. The new 1⅞-in.-diameter, 1.3-lb Rocker solenoid is designed for strokes from 0.01 to 0.06 in. At 0.01 in. stroke (100 deg F), the compact unit exerts a force of at least 15 lb. A power source of 18-30 V dc is needed. Coil resistance at 1000 deg F is 35 ohms.

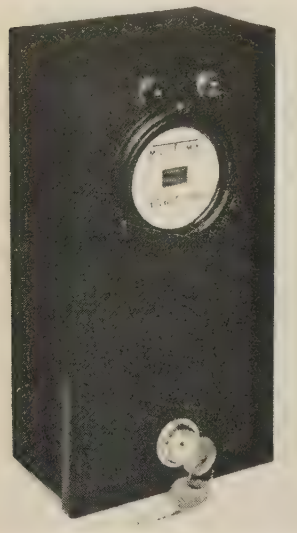
Write in No. 141 on Reader Service Card at start of Product Preview Section

This award is made in recognition of outstanding service performed through the development and manufacture of a product contributing to the advancement of the aerospace industry.

Randolph Hawthorne
Editor

product preview

RECORDER
aids incentive measurement



The Meltime Arc Time Recorder, which gives the precise amount of time involved on any job for Arcair, or welding, work performed, is the most accurate recording tool available to industry for calculating incentive rates, according to **Arcair Co., Dept. S/A, Box 431, Lancaster, O.** The device records arc time down to tenths of a minute, and its clock reading is plainly visible.

The recorder eliminates difficulties arising from human error in measuring Arcair operations from the standpoint of length, depth, weight, and time.

Write in No. 488 on Reader Service Card

CONTROL VALVE
reduces flow variation

This new ¼ in. Flow Control Valve, which is both pressure and temperature compensated, minimizes flow variation brought about by oil temperature changes in missile-handling hydraulic systems. The temperature-sensing mechanism automatically varies orifice size to compensate for concurrent changes in fluid viscosity, and has reduced average flow variations due to temperature changes by 75 per cent, says **Vickers, Inc., Dept. S/A, 172 E. Aurora St., Waterbury 20, Conn.**

The new valve replaces 12 models in the five to 1000 cu./min flow range and is interchangeable with any of them. It incorporates a built-in hydrostat to compensate for load changes. It needs no external drain with associated piping and an integral check valve provides for maximum reverse flow rated at 1,400 cu in./min.

Write in No. 489 on Reader Service Card

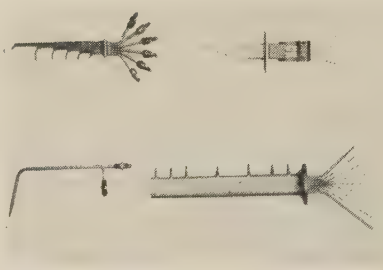
O-RINGS
from new compound

O-ring seals with characteristics for use in high temperature hydraulic service are now offered. Formulated of Parker compound number N-304-7, this new synthetic rubber material meets physical and functional requirements of MIL-P-25732 (ASG), says **Parker Seal Co., Dept. S/A, 17325 Euclid Ave., Cleveland 12, Ohio.**

From this compound, for a temperature range of —65 to +275 deg F, o-rings are molded in all standard sizes. For military aircraft usage, the seals are available in the MS28775 series in bonded stock package.

Write in No. 490 on Reader Service Card

SENSING PROBES
for missile systems



The temperature and pressure sensing probes and rakes in this line have been designed for the measurement of heat, velocity, or thrust of jet engines and missile propulsion systems, says **Pemco, Inc., Dept. S/A, 5663 Brecksville Rd., Cleveland 31, O.** The instruments, which can be fabricated to specifications in a great variety of metals, include bellmouth compressor, turbine and water cooled rake types.

Total pressure, static pressure or pitot static probe types are available, as are units for temperatures to 1500, 2500 and 4000 deg F. The highest temperature type is water cooled.

Write in No. 491 on Reader Service Card

SYNCHRONOUS MOTORS
in new sizes

The availability of size ten and 11 hysteresis synchronous motors is announced by **Western Gear Corp., Dept. S/A, 132 W. Colorado St., Pasadena, Calif.**

The motors are available for 26, 55 or 115 V ac 400 cycle operation. These are six pole units with a pull in torque of 0.12 oz in. and operate at 8,000 rpm. They are designed for use in ambient temperatures from —65 to +125 deg C. The motors measure 1-$^{11}/_{32}$ in. in length.

Write in No. 492 on Reader Service Card

WELDED RELAY
keeps contacts clean

A significant reduction in contact contamination has been achieved in a micro-miniature relay through application of all-welded construction, according to **General Electric Co., Dept. S/A, Schenectady 5, N.Y.** Inert arc welding is used to seal header to can in the four-pole, double-throw relay; no solder is used.

Electrical life of the one-oz unit at its rated two amps (26.5 V dc or 115 V ac) is reported to exceed 200,000 operations. Operate and release times are six and four msec, respectively, including bounce, and pickup power is 400 mw. The relay has a temperature range of —65 to +160 deg C, and it is suitable for use in aircraft and missile electronic systems. Other features include ceramic actuator and ceramic coil spool, symmetrical circuitry, and socket mounting that is designed to prohibit incorrect plugging.

Write in No. 493 on Reader Service Card

DIELECTRIC TEST SET
in two models

This Biddle Dielectric Test Set 5KV-1 MA comes in both fortable and bench models. This maximum output is five ma at output voltage up to 2.5 kv for step-voltage resistance tests, voltage withstand, breakdown, and one minute resistance tests on insulation in electrical equipment with voltage ratings in the 300, 600 and 2500 V classes, says **James G. Biddle Co., Dept. S/A, 1316 Arch St., Phila. 7, Pa.**

The bench model, it is claimed, is ideal for making acceptance and proof test on electrical insulating systems for quality control in manufacturing and repair, while the portable set, housed in a shock and wear resistance case, lends itself to severe field use for test of reconditioned equipment after installation, and in preventive maintenance of installed electrical equipment. Featured is easy portability, small size and a weight of 26 lb.

Wite in No. 494 on Reader Service Card

more on page 208

No. 17 • Mars Outstanding Design Series

LIGHT TRAVEL – You may need to postpone your trip a half century or more but you will make up for lost time. So says Philip Schlesinger, of Buffalo, N. Y., who designed this light-powered space ship which will take you to distant space at almost the speed of light.

Based on Einstein's theory that matter can be converted into light, this Photon Powered ship derives its basic power from a small atomic reactor. The reactor is housed in a unit which also contains reflectors. Comparable to fluorescent screens, these convert the reactor heat, under great pressure, into light and thrust. The thrust is low, but extremely constant.

Launched disassembled inside a cargo rocket, the ship is assembled in space. It cannot land (a landing vehicle is provided for that purpose), but remains in orbit.

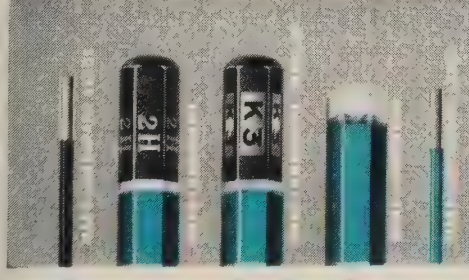
This is one more example of the creative contributions today's designers are making. To help them translate their pace-setting ideas from concept to reality, they require the best of drafting tools.

In pencils that means MARS, long the standard of professionals.

Among the famous imported Mars drafting products are: **Left** – 1001 Mars-Technico push-button lead holder. **Above** – 1904 Mars-Lumograph drawing leads, 18 degrees, EXB to 9H. **Below** – 2886 Mars-Lumograph drawing pencils, 19 degrees, EXEXB to 9H; 2830 Mars-Lumograph Duralar—for drafting on Mylar®-base tracing film – 5 special degrees, K1 to K5; Mars-Lumochrom colored drawing pencils, 24 shades. **Not shown** – Mars Pocket-Technico for field use; Mars pencil and lead sharpeners; Mars Non-Print pencils and leads.

Mars Products are available at better engineering and drafting material suppliers.

®T.M. FOR duPONT'S POLYESTER FILM



for the man who's going places...

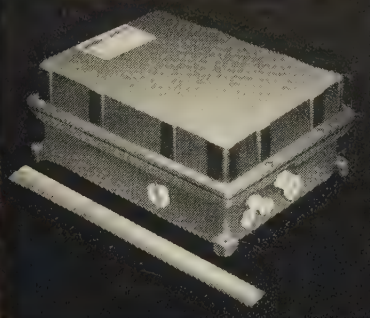
the pencil that's as good as it looks

MARS

Sold at all good engineering and drawing material suppliers • J. S. STAEDTLER, INC. • Hackensack, N. J.

Write in No. 142 on Reader Service Card at start of Product Preview Section

NOW AVAILABLE FROM GENERAL ELECTRIC . . .
TRANSISTORIZED
C-BAND BEACON



1/7 cubic ft.—9.8 lbs.*

Here's how you can save design, development and production costs. G.E.'s transistorized C-Band Beacon, originally designed and tested as a spaceborne tracking aid for ballistic missile applications, is now available for tracking and identification of all types of missiles, drones and aircraft. Extremely compact (9.8 lbs., 9.63 x 7.00 x 3.88 inches), G.E.'s transistorized C-Band Beacon offers you such outstanding advantages as a guaranteed High Peak Power Output with extremely Low Power Consumption, Proven Reliability in a Single Package (Power Supply Included), and Single or Double Pulse Interrogation. And, this beacon is available within four months of your order. Get more information today about this unusual beacon package.

**$9995.95 in quantities of 20; (Lower prices for Large Quantities)*

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General Electric Company
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☐ Please send me your descriptive bulletin
☐ Please have your sales engineer contact me

Name _____
Title _____
Company _____
Address _____
City _____ State _____

GENERAL ELECTRIC

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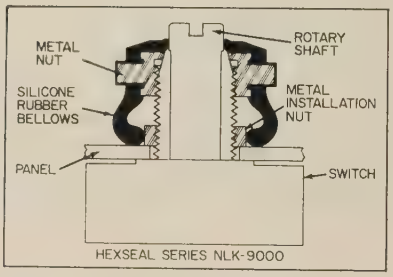
DC ACCELEROMETERS use no amplifiers

Combined in these dc accelerometers are a solid state carrier oscillator and ring demodulator with a variable reluctance pickup. This results in compact transducers utilizing dc excitation and providing dc output at constant impedance, low hysteresis, excellent linearity, and high natural frequency. Because of the high output of the unit, no amplifiers are needed, says **Wiancko Engineering Co., Dept. S/A, 255 N. Halstead, Pasadena, Calif.**

These accelerators are said to be ideally suited for missile testing, and for use in airborne and ground based data systems.

Write in No. 495 on Reader Service Card

PRESSURE SEAL for locking type shafts



A seal for locking type shafts, Hexseal®, Series NLK-9000, are intended for use with Allen Bradley potentiometers, Type J, and similar adjust-and-lock components, says **A. P. M. Co., Dept. S/A, 252 Hawthorne Ave., Yonkers, N.Y.**

The basic design is a one-piece silicone rubber bellows molded to a metal nut. The bellows seals against the panel and an inwardly protruding zero rib seals against the rotary shaft. The series are also available to fit all standard thread and shaft sizes. The materials used are unaffected by salt water, acids and ozone. They are useful over the temperature range of —160 to 500 deg F.

Write in No. 496 on Reader Service Card

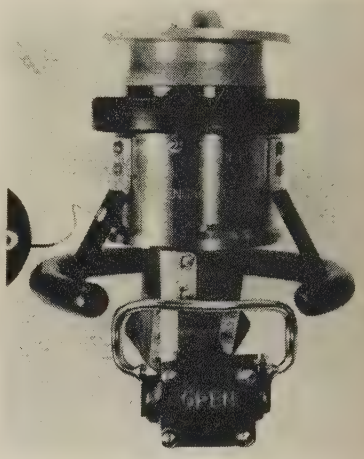
KEYBOARD SWITCH has six poles

This keyboard switch, available in either push on - push off or momentary, is designed for light-action keyboard type installations where additional switching circuits are required. Need for relay banks is eliminated along with space and weight problems. The six independent poles can be supplied in any combination of normally open or closed contacts, says, **Pendar, Inc., Dept. S/A, P.O. Box 3355, Van Nuys, Calif.**

The switch is made with one to two lb operating pressure, ½ in. mounting thread, ¾ in. case diameter, 3/16 in. travel and ½ ampere inductive contacts at 28 V dc. Push buttons can be supplied in various colors and shapes, engraved to individual customer requirements.

Write in No. 497 on Reader Service Card

NOZZLE AND ADAPTER for hydrogen peroxide



This is a new self-sealing, high flow rate hydrogen peroxide nozzle and adapter for servicing aircraft or missiles using hydrogen peroxide as an oxidizer. For safety, the nozzle must be manually locked to the adapter before the internal valves can be actuated and, the internal valves must be completely closed before disengagement. Another important feature of this nozzle is that all working parts are fitted externally and do not come in contact with the fluid, eliminating the possibility of corrosion, says **Flight Refueling Inc., Dept. S/A, Friendship International Airport, Box 1701, Baltimore 3, Md.**

The adapter is available in sizes from 1½ to six inches.

Write in No. 498 on Reader Service Card

FREQUENCY GENERATOR for L-band

Model RD 175 frequency generator covers the range from 1.095 to 1.405 kmc. The output is held stable to better than 1 part in 10^8 per day, says **Manson Laboratories, Inc., Dept. S/A, PO Box 594, 207 Greenwich Ave., Stamford, Conn.** The output is tunable over the range in 10-mc steps and is a minimum of 50 mw to a 50 ohm load.

Based on crystal synthesizer design techniques, the instrument essentially employs a disciplined VFO driving a tunable multiplier cavity, from which output is taken. Stability is controlled through a feedback system in which the VFO is phase-locked to a reference spectrum. Dimensions are 5¼ by 10 by 19 in.

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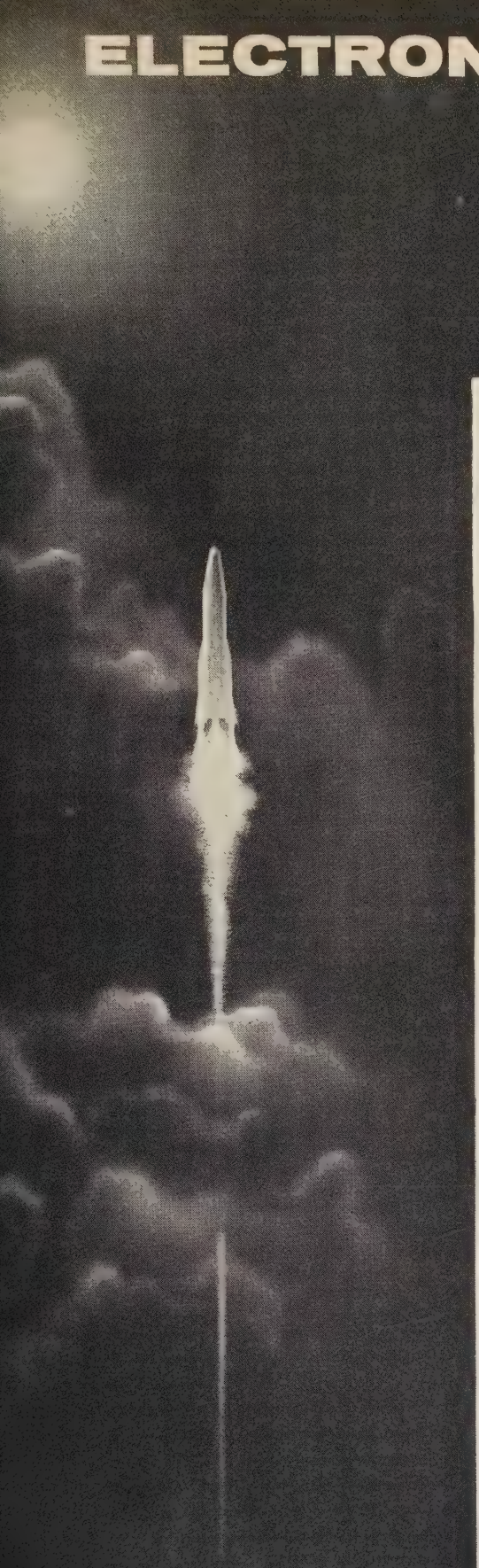
more on page 211

Write in No. 144 on Reader Service Card

ELECTRONIC DETECTION...

tremendous challenge to creative engineers in a field whose growth must parallel the space age



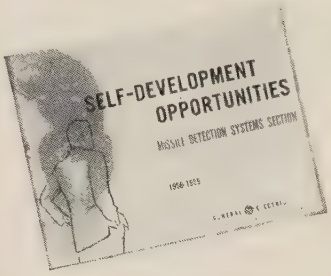
. . . At General Electric, detection system engineering has become a profession in itself—offering electronic engineers financial and career opportunities not found in many other electronics fields.

Advanced radar detection systems offer probably the most effective method of determining location, direction, and speed of in-flight missiles or aircraft. And the General Electric Company has—and continues to—play a leadership role in the conception, design, and development of advanced radar detection systems for science and National Defense.

In line with this role General Electric needs more qualified personnel. Right now, General Electric needs electronics engineers, mathematicians, data processing specialists with the capabilities to make positive contributions toward the solution of urgent defense problems.

But unlike many companies, General Electric offers qualified personnel—with a minimum of three years in radar design and development or related phases—career opportunities with the growth potential they have been looking for.

Whether this challenge interests you or not, why not compare, for example, General Electric's self-development opportunities in the privacy of your own home.



Compare self-development opportunities at General Electric

- ☐ **Please send me your brochure describing your self-development program.**
- ☐ **I am enclosing my resume for your consideration.**

T. M. George
Section A228-5
Missile Detection Systems Section
General Electric Company
Syracuse, New York

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DEGREE _____

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CITY _____ **STATE** _____

MISSILE DETECTION SECTION
HEAVY MILITARY ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

GENERAL ELECTRIC ANNOUNCES . . .

Two new, ultra-small relays

From the company which first introduced the revolutionary micro-miniature relay in 1955 come two more important new developments in sealed-relay miniaturization.

General Electric has added the world's smallest one-amp relay, the single-pole Unimite, and a new four-pole micro-miniature to its sealed-relay line. Both new relays incorporate an important advance in relay manufacture. No solder and no solder flux are used anywhere in either relay's structure. A new inert-arc welding process seals headers to cans, eliminating a major cause of contact contamination.

The new Unimite and four-pole relays lend themselves admirably to printed-circuit-board work. The Unimite relay can be soldered into the board or is available for stud, lug, or bracket mounting. Its flexible leads can be formed or fanned for any circuit requirement. The four-pole relay terminations are on 0.2 inch centers in accord with the popular grid-spaced pattern.

These new relays, combined with a full line of miniature and double-pole micro-miniatures, offer equipment designers a new dimension in relay flexibility. Both new relays meet or exceed applicable requirements of MIL-R-5757 and MIL-R-25018.

All General Electric sealed relays combine minimum size with unmatched reliability under severe shock, vibration, and temperature conditions. For complete information on G.E.'s full line of sealed relays, contact your G-E Apparatus Sales Office or mail coupon at the right. General Electric Co., Specialty Control Dept., Waynesboro, Va.

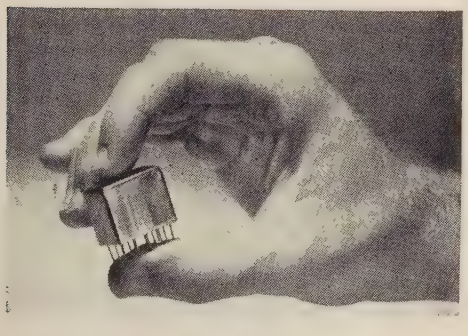
Progress Is Our Most Important Product

GENERAL ELECTRIC

Write in No. 145 on Reader Service Card at start of Product Preview Section

Unimite is world's smallest 1-amp relay

The slim cylindrical shape of the new Unimite relay saves space in the important vertical dimension. Its high-speed operation—operates in 1.5 milliseconds max., release time 3.5 milliseconds max. —offers a new approach to automatic switching. Its welded, totally isolated contact capsule eliminates organics from switching chamber, provides lifetime freedom from contact contamination. Every Unimite is a dry-circuit relay.



4-Pole micro-miniature suited for 160C ambient

New micro-miniature provides four-pole configuration and exceptionally long life performance—minimum of 10 million low-level operations, test units have run over 50 million operations. Suitable for continuous operation in a 160C ambient, the relay provides a valuable safety factor in application to 125C equipments. Vibration performance is excellent; it withstands 55 to 2000 cycles at 30G acceleration without contact opening. Operate power is only 400 mw.

General Electric Company
Section E792-12
Schenectady, New York

Please send me a free copy of the 1959 Sealed Relay Catalog.

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GENERAL ELECTRIC

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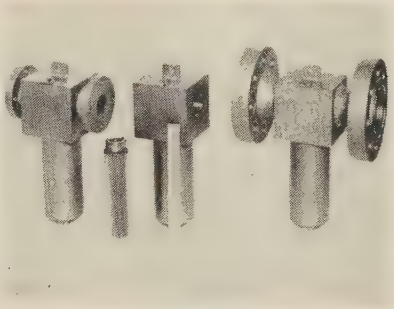
T-FILTERS for ground equipment



These Model 12680 heavy-duty in-line T-Filters for ground equipment use are now available. One basic design using an interchangeable element can be supplied with different flange sizes, NPT or AND ports, facilitating applications to a wide variety of systems, says **Bendix Filter Div., Bendix Aviation Corp., Dept. S/A, 434 W. 12 Mile Rd., Madison Heights, Mich.**

The units will handle nitrogen, helium, oxygen, and air at flow rates up to 20,000-scfm at pressures up to 5,000 psi. Liquids including JP-fuel, water and hydraulic oil can be filtered at flows up to 150 gal per min. The filter element is stainless steel and will withstand temperatures up to 500 deg F. Pore sizes range from five to 250 microns. The filter unit head and bowl are stressed for both 3000 and 5000 psi systems with 4:1 safety factors on burst. These units range in overall dimensions from 6½ in. long by 16-⅜ in. deep to 16½ in. long to 20-7/16 in. deep.

Write in No. 267 on Reader Service Card

MOTOR GENERATORS for advanced use

This basic servo motor-generator design, is being produced in sizes eight, ten, 11, 15, 18, and 20, and with modifications to meet special applications. The high torque-to-inertia characteristic of these units offers high acceleration and immediate accurate response to error signals, says **Induction Motors Corp., Dept. S/A, 570 Main Street, Westbury, Long Island, N.Y.**

Characteristics of the size eight generator are: input: 18V 400cps, 1.65 W; voltage gradient per 1000 rpm: 0,27V; temperature range: −55 to +150 deg C; null voltage (max): 0.015V rms; phase shift: within ten degrees of reference; weight: 2.86 oz; outside diameter: 0.750; overall length: 2-1/32. Characteristics of the size eight motor are: input: 18V 400-cps, 4.7 W per phase; torque at stall: 0.42 oz in.; no load speed: 6200 rpm; power factor: 0.875; Rotor inertia: 0.75 gm cm^2; theoretical acceleration at stall: 38,000 rad/sec^2.

Write in No. 268 on Reader Service Card

TEST CONSOLE for up to 20,000 psi

This Model 9500 Test Console is a self-contained laboratory type instrument for static and dynamic testing of hydraulic missile components. The automatically regulated high-pressure oil system delivers up to 20 gpm at 3000 psi or 9.7 gpm at 5000 psi. A manually-operated high-pressure source produces 20,000 psi for static testing, says **George L. Nankervis Co., Dept. S/A, 15400 Fullerton Ave., Detroit 27, Mich.**

An automatic temperature regulating system, consisting of a heat exchanger and immersion heaters, controls test fluid temperatures to ± 2F from ambient to 350 F MIL H 5606, MIL O 7808 or Ornite 8515 oils can be used interchangeably without replacing seals or other components. A 40 hp electric motor drives a variable volume pressure compensated pump for component testing.

Write in No. 269 on Reader Service Card

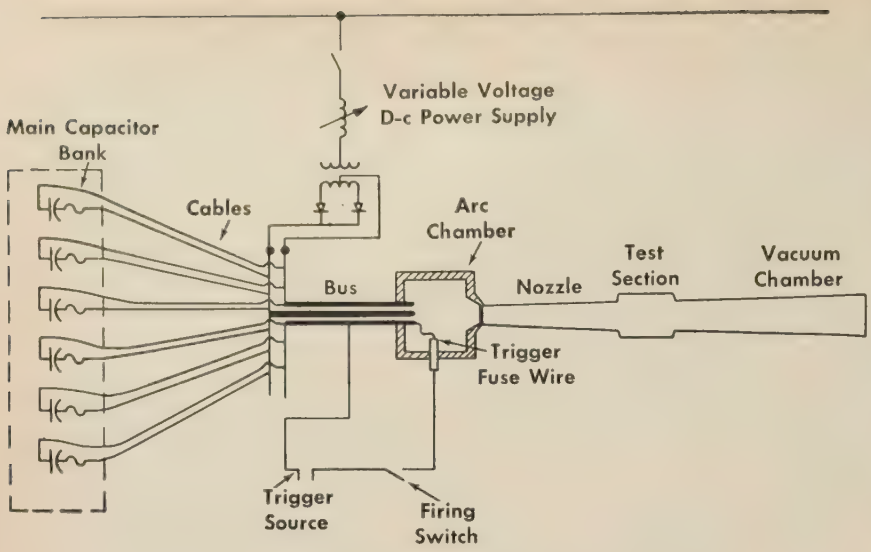
MULTIPOINT RECORDER has change-over kit

This new multipoint recording potentiometer, Model 6702, is capable of handling from two to 24 points by means of simple plug-in adapter units. The instrument is designed to measure any number of variables by means of a simple and inexpensive kit of change-over parts, says **Weston Instruments, Dept. S/A, Newark 12, N.J.**

The problem of range changing, it is said, requires only the insertion of the proper range clip. A change in the type of thermocouple or transducer being used is made by replacing a terminal block which has the cold junction compensation integrally wired into it. Inserting the matching range clip and scale plate, included in the thermocouple change kit, completes this procedure. The unit can be used to measure any inputs from thermocouples or transducers, whether they be voltages, frequencies, temperatures, pressures, pH, etc.

Write in No. 270 on Reader Service Card

more on page 213



General Electric capacitors supply 5-million amp arc to create Mach 27 conditions in wind-tunnel research of missile and space vehicle design. Vaporized fuse wire shorts electrodes in pressure chamber, dumping capacitors' charge of 7-million watt-seconds in brief arc. Diaphragm bursts, releasing hypersonic shock wave past model in tunnel's test section.

Shown above is a section of a 2-million joule capacitor bank, specially designed and built by General Electric for the investigation of controlled thermo-nuclear reactions.

General Electric Capacitors Power Space-age Research

Capacitive energy-storage and discharge systems energize man-made thunderbolts for scientific studies

A NEW "HOT SHOT" WIND TUNNEL, being installed by the Boeing Airplane Company of Seattle, Washington, will be powered by a General Electric capacitor system. This installation will provide temperatures up to 25,000 F and pressures of 30,000 psi to create a hypersonic blast of air for missile and space-vehicle research. Electric energy for winds up to 27 times the speed of sound will be stored in a bank of over 2000 General Electric capacitors.

G-E CAPACITOR SYSTEMS, backed by over 30 years of research and development, are today proving an economical and efficient tool in industry's continuing investigation of complex space-age problems.

CAPACITORS OFFER THE OPTIMUM in high efficiency, speed of discharge, and dependability and economy of operation. Properly designed and installed, they will safely store the energy required and discharge it in fractions of a second.

GENERAL ELECTRIC RESEARCH has provided not only improved capacitors, but complete capacitor systems. For example, a G-E installation provides special fusing developed to protect both personnel and equipment from the high currents involved. Unwanted resistance and inductance are kept to a minimum for low losses and fast discharge; not only in the capacitors themselves, but in the connections and cabling needed to tie the individual components into an efficient system.

FOR A COMPLETE G-E PACKAGE, charging equipment, rectifiers, controls, protective devices, racks, and various other components are coordinated. In addition, installation and testing are supervised by qualified General Electric personnel so that a finished unit is delivered, ready for use.

THE SINGLE SOURCE OF SUPPLY provided by General Electric offers you a complete energy-storage and discharge system, whether your work involves the use of wind tunnels or that of plasma generators, ionic propulsion, impulse test apparatus, and others. For either thousand-unit banks or a few units, General Electric provides qualified engineering and installation assistance to meet your particular requirements.

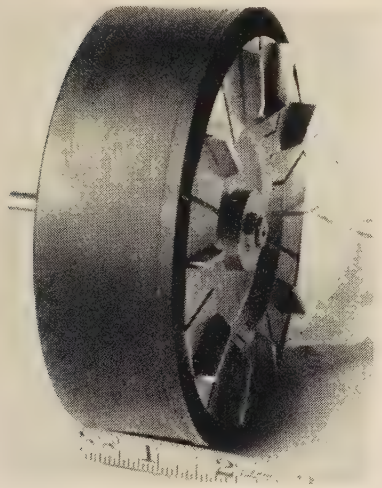
FOR FURTHER INFORMATION, contact your nearest Apparatus Sales Office or sales representative, or write Section 447-6, General Electric Co., Schenectady 5, New York.

Progress Is Our Most Important Product

GENERAL ELECTRIC

Write in No. 146 on Reader Service Card at start of Product Preview Section

HYSTERESIS MOTOR is very flat



This new type of synchronous motor, designed especially for the tape recorder, instrumentation, and the missiles field, is an axial air gap type and the stator is made of a continuous steel silicon strip, punched and coiled. The motor is less than two inches deep over all. Model 6-10.20 runs at 360 and 720 rpm giving direct drive for 3-¾ and 7½ ips. It is five inches in diameter and weighs four pounds, says **Charles B. Stegman, Assoc., Dept. S/A, 5757 Tobias Ave., Van Nuys, Calif.**

Capstan size is 0.1998 hardened and ground to a tolerance of 0.00025 F.I.R. Torques developed for starting and running are 360 rpm 4&5 in. oz. 720 rpm 5/6 in. oz. Stray field with out shield better than —40 dbm with shield better than —60.

Write in No. 271 on Reader Service Card

TOGGLE SWITCH is subminiature

This subminiature toggle switch, the Unimax Type 2SBI-1, is said to combine the advantages of double circuit control, single hole panel mounting, and a toggle actuator, with subminiature size. The assembly comprises a pair of Unimax Type USM5 switches, secured in a mounting bracket, with a two-position toggle mechanism. The ¼ in. —40 threaded bushing permits single-hole mounting in panels up to ¼ in. thick. The 2sB-1 switch requires back of panel space $^{25}/_{32}$ in. long by $^{21}/_{32}$ in. wide and $^{21}/_{32}$ in. deep. The two basic switches in this unit meet MIL-S-6743 and MIL drawing MS-25085-1, says **Unimax Switch Div., W. L. Maxson Corp., Dept. SA, Ives Rd., Wallingford, Conn.**

Electrical ratings of each basic switch are: 2.5 amperes, 30V dc, inductive; five amperes, 30V dc, resistive; five amperes, 125/250V ac, single-pole, double-throw action.

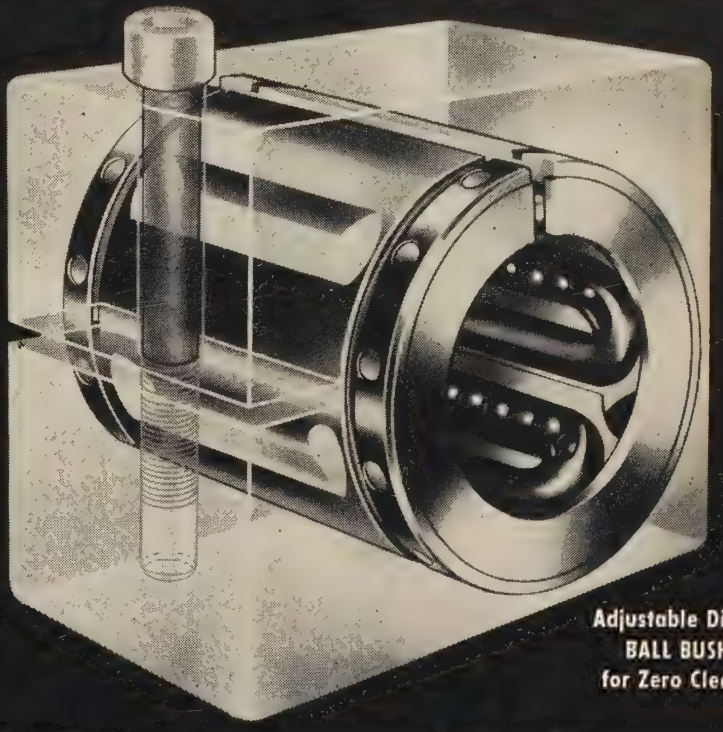
Write in No. 272 on Reader Service Card

more on page 216

Write in No. 147 on Reader Service Card

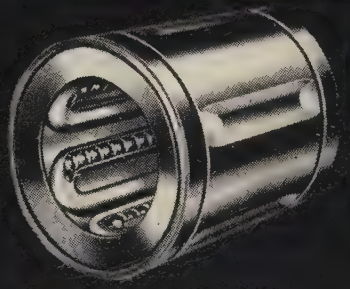
NOW! *Adjustable Diameter and Open* THOMSON

BALL BUSHINGS

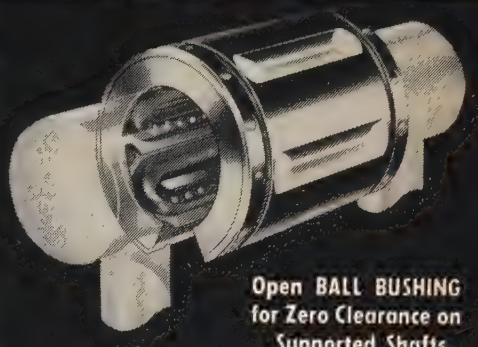


Adjustable Diameter BALL BUSHING for Zero Clearance

The BALL Bearing for *all* your **LINEAR MOTIONS**



Precision Series "A" and Low Cost Series "B" BALL BUSHING



Open BALL BUSHING for Zero Clearance on Supported Shafts

Sliding linear motions are nearly always troublesome. Thousands of progressive engineers and designers have solved this problem by application of BALL BUSHINGS on *guide rods, reciprocating shafts, push-pull actions,* or for support of *any mechanism that is moved or shifted in a straight line.*

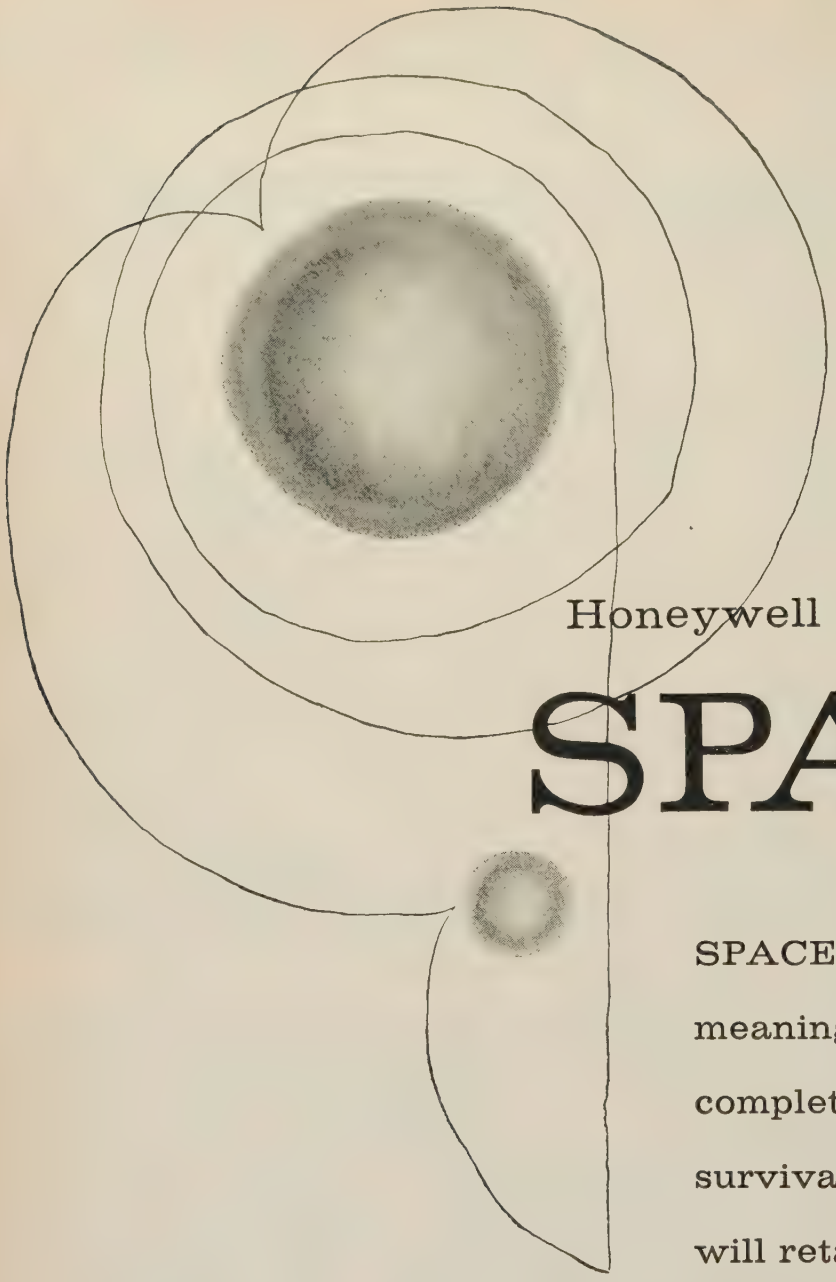
Improve your product! Up-date your design and performance with Thomson BALL BUSHINGS!

LOW FRICTION • ZERO SHAKE OR PLAY
ELIMINATE BINDING AND CHATTER
SOLVE SLIDING LUBRICATION PROBLEMS
LONG LIFE • LASTING ALIGNMENT

The various types cover a shaft diameter range of ⅛" to 4". Small sizes available in Stainless Steel. Write for literature and name of our representative in your city.

THOMSON INDUSTRIES, Inc.
Dept. D, MANHASSET, NEW YORK

Also Manufacturers of NYLINED Bearings . . . Sleeve Bearings of DuPont Nylon, and GO CASE . . . Hardened and Ground Steel Shafting



Honeywell calls it

SPACEA

SPACEABILITY is a new term meaning the capability to completely equip man for survival in space. While he will retain the ability to exercise his judgment with manual controls, man's welfare in space will depend largely on automatic control of his navigation, flight and power—in fact, his total environment, including food, oxygen and waste disposal.

There are three areas indispensable to space operations: (1) motion control and navigation for vehicles of flight, including inertial systems; (2) environmental control for human activity; and (3) instrumentation and data processing both on the ground and in the air.

Recognition of Honeywell leadership in all three areas is exemplified by the fact that Honeywell controls are going into almost all space vehicles presently planned.

BILITY

This Honeywell capability is benefiting the following projects, some of which have already been completed:

- Providing complete guidance and flight control system for Project Scout, the NASA launching vehicle for orbital and probe flights of instrumentation satellites.
- Developing navigation and guidance system for the proposed Martin version of Dyna-Soar, the Air Force pilot-controlled semi-orbital vehicle.
- Developing and producing an advanced space cabin environment simulator for the Air Force School of Aviation Medicine.
- Supplying orbital injection guidance reference systems for Project Vanguard's launching of satellites into predetermined orbits.
- Developing and producing attitude control for both orbiting and re-entry versions of Project Mercury, the NASA manned satellite program.
- Developing and producing attitude stabilization systems for vehicles used in re-entry test phases of Project Mercury.
- Human engineering studies and instrumentation development for pilot orientation in space flight for Project Mercury.

Corporate capability—With a notable background in missile and space systems management, as well as in the design, development and production of systems and components, Honeywell is fully qualified for work on all phases of prime missile and space systems.

Human engineering in relation to space flight is being studied by an entire project team at the Military Products Group's aeronautical facility in Minneapolis. The group is made up of specialists in anthropology, anthropometry, bio-chemistry, bio-physics, psychology and psycho-servo analysis. Their goal: optimum integration of man into a complex control system, which involves problems such as efficiently dividing labor between manual and automatic computation equipment.

Honeywell organization makes available to space projects unique capabilities and experience. These include Industrial Instrumentation, Computing and Recording complex; the services of environmental experts in the Temperature Controls Group; and associated members of the Military Products Group: Ordnance, Aeronautical, Boston, and Missile Equipment Divisions. The Corporate Research Center works closely with all groups.

Areas of interest and activity at Honeywell for space projects include the following:

Inertial guidance and navigation systems, gyros, stable platforms, accelerometers, computers, air data systems, ballistic trajectory control systems, horizon scanners, fix takers, reaction jets, control valves.

Other areas are flight data sensing and display systems, telemetry and recording systems, data reduction systems, pressure and temperature sensors, analog-digital and digital-analog converters, atmosphere composition control systems, temperature control systems, pressure control systems and recording devices.

If you have a problem that requires outstanding capability in control for space projects, call on Honeywell. For information write Honeywell, Minneapolis 8, Minn.

Honeywell

H HONEYWELL *Military Products Group*

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Cleaning Problem?

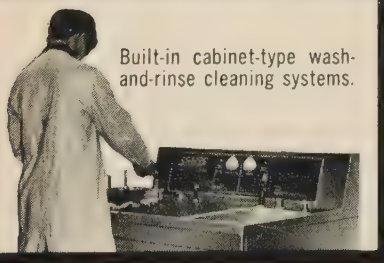
SONOGEN®

Ultrasonic Cleaners by

BRANSON

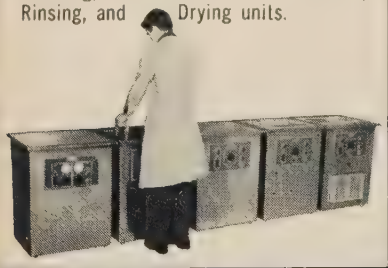
may be your answer!

½-gallon and larger benchtop models, and (illustrated) 5- and 12-gallon self-contained rollaround units.



Built-in cabinet-type wash-and-rinse cleaning systems.

Modular cabinet-type systems with Cleaning, Filter / Heater / Recirculator, Rinsing, and Drying units.



Custom-engineered cleaning installations: for batch and conveyorized cleaning, and for continuous-flow cleaning in strip and wire mills.

Branson offers experienced counsel in adapting the flexibility of SONOGEN® Ultrasonic Cleaning Equipment to **your** needs. Tell us the problem, and we'll follow through from planning and installation to maintenance, with factory-trained specialists available nationwide.

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BRANSON: Send SONOGEN® Bulletin

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MOTOR
does work of two units

This mechanical pneumatic motor, the CSD-S, starts as well as supplies electrical power for turbo-jet and turbo-prop aircraft. In one package it is a constant speed drive as well as a starter, is 15 in. long, 12 in. in diameter and weighs 50 lb. Weight saving in a typical 60 kva airborne installation is well over 100 lb, says **Garrett Corp., Dept. S/A, 402 S. 36th St., Phoenix, Arizona.** The unit, it is said, not only performs well at sonic speeds but also at speeds of Mach three or four or about 3000 mph.

Functions of the motor include: complete pre-flight check out of an aircraft's entire electrical system without the main engines operating; starting the main engines; automatically shifting to a constant speed drive when starting is completed and supplying shaft power for electrical conversion. It can also supply secondary power to operate all the aircraft's accessories while in flight including hydraulic components.

Write in No. 273 on Reader Service Card

OIL PRESSURE TRANSMITTER
for jet engines

This miniature, aircraft oil pressure transmitter, Model 318, capable of being mounted directly on jet engines withstands vibration to 2000 cps at 20g, weighs one pound, is two inches in diameter, has an overall length of 3⅝ in. and meets MIL-T-26638, says **Thomas A. Edison Industries, Dept. S/A, West Orange, N.J.** Three different indicators are available for use with the transmitters.

The system is available for ranges of zero to 60 and zero to 100 psi. The transmitters and indicators operate on 26V 400 cps power and are connected by means of three No. AWG 20 copper wires. The transmitter is a variable reluctance type instrument having no bearings, linkages or moving coils and requiring no lubrication. It withstands environmental temperature of +232 to —65 deg C.

Write in No. 274 on Reader Service Card

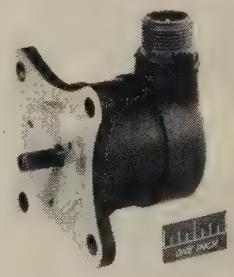
POWER UNITS
in two models

This Model P-1031D Electric Hydraulic Power Unit for use on missiles and rockets performs in fluid and ambient temperatures of —65 to +125 deg F when using MIL-H-5606 as the hydraulic fluid. Pump rating is 0.75 gpm at 3,000 psig discharge pressure at 10,000 rpm and having a duty cycle of three minutes on and 30 minutes off. Pump is one pound and when coupled to 28 Vdc electric motor total weight is 7¾ lb. Minimum life is 200 hrs. It is 9$^{13}/_{16}$ in. long, says **Lear-Romec Div., Lear, Inc., Dept. S/A, Elyria, Ohio.**

Model P-103E Hydraulic Power Unit, now under development testing uses unsymmtrical dimethylhydrazine at an input flow to the motor not exceeding eight gpm and 700 psig. Excessive flow not required by the motor is bypassed through an integrated flow control valve. This fuel limits maximum operating temperature to 110 deg F. Other fluids may be used to extend maximum operating temperature to 275 deg F or higher, it is claimed. Pump rating is 0.75 gpm at 3,000 psig discharge pressure at 10,000 rpm. Hydraulic motor is an external, rotary, spur gear design. Complete unit weighs three pounds. It is 6⅞ in. long.

Write in No. 275 on Reader Service Card

TACHOMETER GENERATOR
features reduced weight



The development of a miniature tachometer generator to replace its previous line for jet aircraft is announced by **General Electric Co., Dept. S/A, Schenectady 5, N. Y.**

The new two-pole, three-phase generator, it is said, represents a weight reduction from 26 to 12 oz with a comparable size decrease. The generator is rated for continuous operation at 350 deg F. They say, this has been accomplished without sacrificing any performance characteristics. The new generator is directly interchangeable with the previous larger model.

Write in No. 276 on Reader Service Card

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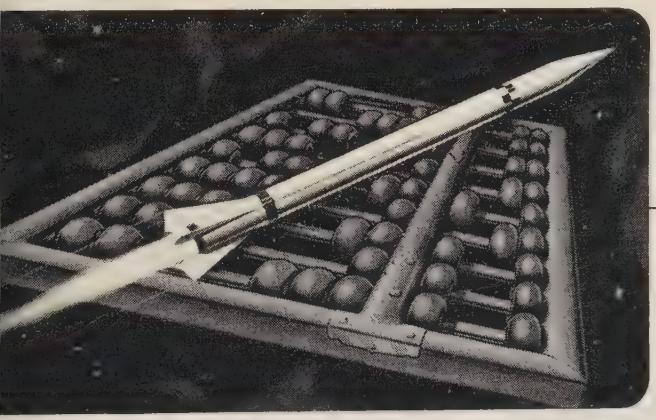
Pioneering Achievements in Electronics at JPL

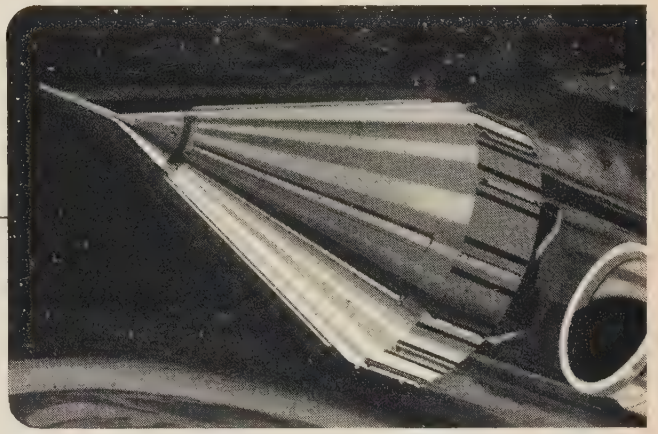
GUIDANCE RESEARCH . . . by JPL has led and advanced the field of missile guidance. Among these achievements are the application of Wiener RMS methods to multiple-input, multiple-loop servos, and matching missile trajectory to missile control transfer function for optimum accuracy.

GUIDANCE SYSTEMS . . . both inertial and radio-command types employing new concepts of radar communication have been pioneered at JPL. This guidance system development activity is supported by basic research in all phases of electronics.

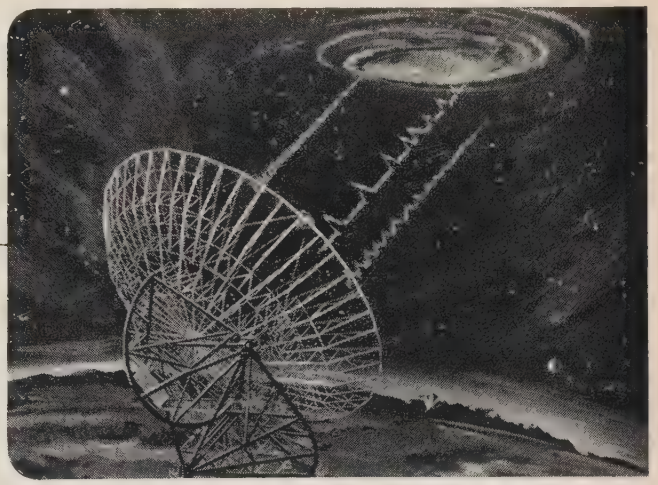


COMPUTERS . . . and the application of computing techniques to missile guidance systems have been pioneered by JPL. The Laboratory is now searching for new techniques that will further advance the state of the art in digital guidance components and computer systems.

DATA TRANSMISSION . . . brings news from space via the Explorer series. Explorer III used a tape recorder the size of a cigarette pack capable of transmitting two hours of information in 5 seconds. Electronic payload weight was approximately 11 lbs.



INSTRUMENTATION . . . of the moon probe provided measurement of radiation environment at distances far from the earth. Telemetered data revealed the existence of high intensity radiation. Miniaturization resulted in an instrument payload weighing only 10 lbs.



COMMUNICATIONS . . . pioneering in interplanetary communications resulted in this giant parabolic radio antenna, 85 feet in diameter, developed by the Laboratory which enables the tracking and reception of scientific data from great distances.

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A Research Facility operated for the National Aeronautics and Space Administration

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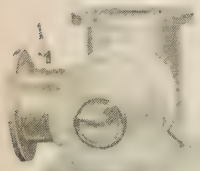
Send professional resume, with full qualifications and experience, for our immediate consideration

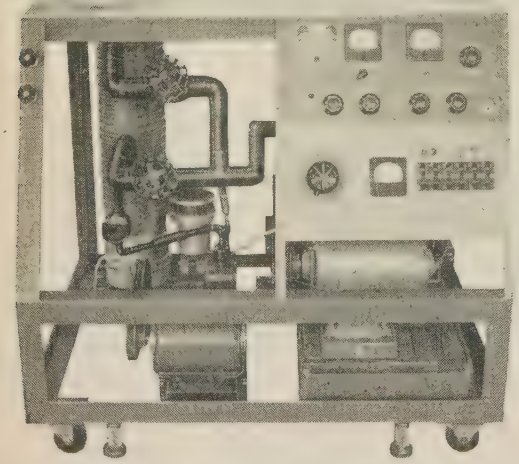
VACUUM

Kinney®

HIGH PERFORMANCE PACKAGED PUMPING SYSTEMS



Built in Models 200, 400 and 600, KINNEY PW Packaged Pumping Systems consist of a KINNEY copper thimble type Cold Trap, Fractionating Oil Diffusion Pump, and two-stage, gas-ballasted Mechanical Vacuum Pump. High visibility instrument panel with all controls and electrical connections within easy reach.



Get the greater utility and versatility built into these KINNEY PW Series High Vacuum Pumping Systems which users call "the workhorses of the modern laboratory." These units will evacuate altitude chambers, tanks, furnaces, ovens, tubes, bell jars or other laboratory equipment, attaining pressures in the order of 5×10^{-6} mm Hg. without coolant in the cold trap and substantially lower when coolant is used.

These units are mounted on casters so that they can be moved readily to serve a variety of facilities, especially those which are fixed installations. A unique and exclusive High Vacuum Valve design enables the operator to rotate the Valve and position the suction connection horizontally, vertically, or at any angle in between. Thus, it is possible with a base plate assembly to quickly convert to an Evaporator.

Bring your file of new developments in High Vacuum up-to-date. Write today.

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Please send me Bulletin 4000.1 ☐ I am also interested in Mechanical Pumps ☐ Oil Diffusion Pumps ☐ Vacuum Furnaces ☐ Evaporators ☐

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CONNECTORS *halve assembly time*

These connectors, called "Quick-Crimp," are partially pre-assembled before shipment into three basic parts (plus an optional boot) and are said to cut assembly time in half. Family has 19 different connectors which mate with standard BNCs if desired, according to **Amphenol-Borg Electronics Corp., Dept. S/A, 1830 S. 54th Ave., Chicago 50, Ill.** Voltage rating is 500 v peak. VSWR is low up to 10K mc.

Center contacts are gold-plated and feature patented "captivated contact" construction.

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MOTOR-GENERATOR SET *is packaged*

This self-contained, two-bearing unit consists of a unity power factor, synchronous motor driving a 50 kw, 0.8 power factor, 400-cycle generator with a precise out of 400 cycles per second at 1200 rpm. Output voltage of the generator is 120/208 volts. It has an integral control panel housing the motor starter and generator output controls. Meters show generator output, frequency, voltage, and amperage, says **Electric Machinery Mfg. Co., Dept. S/A, Minneapolis 13, Minn.**

The unit features static excitation and a magnetic amplifier voltage regulator.

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EPOXY RESINS *resist high heat*

A Mara set epoxy resin system for casting, laminating, and adhesive uses where high heat resistance is required is multi-functional liquid resin in two formulations: 617-A, aluminum filled; 617-C, clear. Both have low viscosity, which can be maintained at room temperature for as long as 30 minutes. After mixture with a marblette hardener for polymerizing, viscosity can be repeatedly relowered to a point suitable for laminating by heating the blend to above 65° C, according to **Marblette Corp., Dept. S/A, 37-31 30th St., Long Island City 1, N. Y.**

In both forms, 617 exhibits heat resistance up to operating temperatures as high as 500° F.

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TRANSDUCERS *have long stroke*

These new smaller differential transformers of which linear stroke is 70 per cent of coil length, feature high output and low impedance secondary windings. These units are designed for linear displacement from ±0.5 to ±8.0 in., says **Automatic Timing & Controls, Inc., Dept. S/A, King of Prussia, Pa.**

The ratio of output voltage, at range limit, to null voltage is 1000:1. Linearity of ±0.5 per cent over a range of —60 to 250 deg F is attainable. These transducers are magnetically shielded, potted, and furnished with teflon insulated leads.

Write in No. 280 on Reader Service Card

CONNECTORS *cut solder pot strain*

A new line of Connector/Cable Adapter Sleeves, GI, are usable where there is insufficient room in an AN type backshell, or usable to adapt any AN connector to any size AN type clamp, says **Glenair, Inc., Dept. S/A, 1401 Air Way, Glendale 1, Calif.**

The use of these adapter sleeves, it is said, removes the possibility of strain at the solder pots and enables a good mechanical clamp to be made at the rear of the connector.

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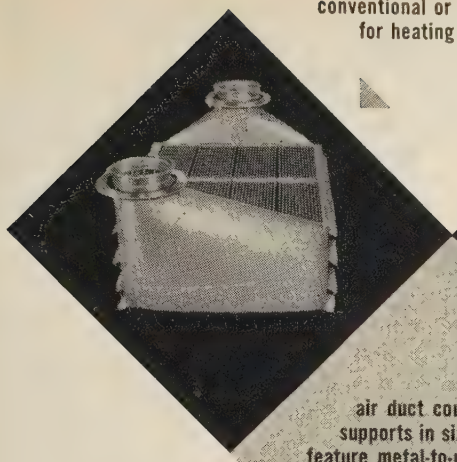
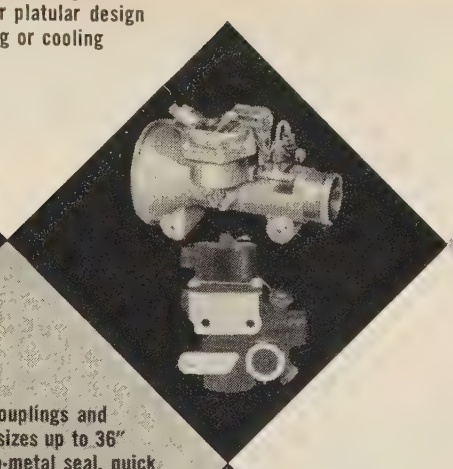
more on page 222

compact heat exchangers of conventional or platular design for heating or cooling





precision pneumatic controls for bleed-air combine functions saving weight and space — special control specs invited

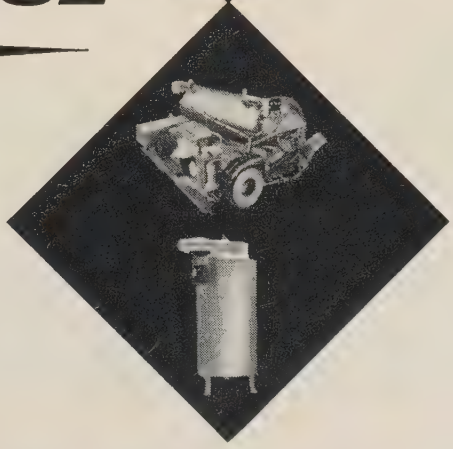
air duct couplings and supports in sizes up to 36" feature metal-to-metal seal, quick disconnects, maximum safety

For a proposal you can rely on contact your Janitrol engineering representative when your plans call for components, pneumatic sub-systems, and complete systems for heat transfer and air control. Virtually every modern aircraft and operational missile incorporates the skills that Janitrol translates into practical hardware. Janitrol Aircraft Division, Surface Combustion Corporation, 4200 Surface Road, Columbus 4, Ohio

liquid heaters for ground support equipment in compact sizes to 1 million Btu/hr — multi-fuel use

combustion systems include hot fuel prime units, inert gas generators and aircraft heaters

JANITROL®



reliable components for missiles / aircraft / support

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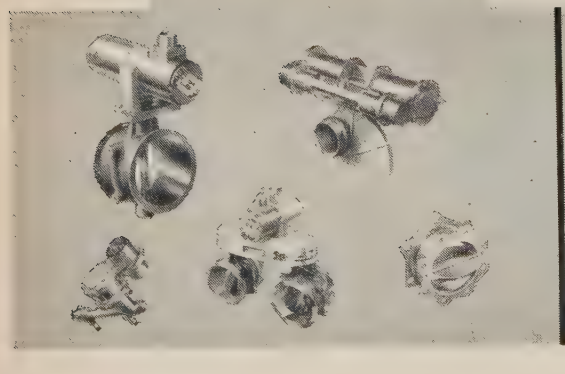
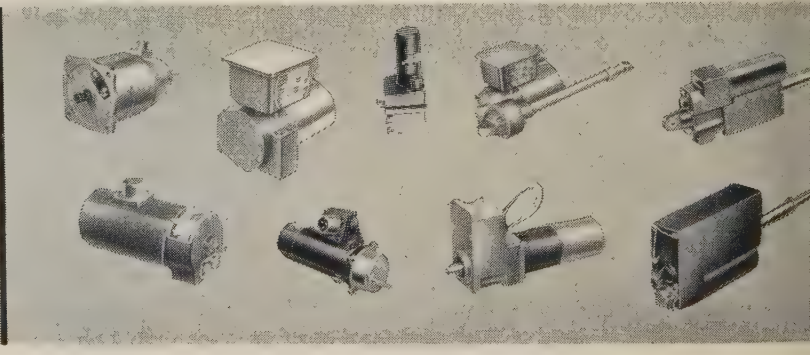
THE MARK OF QUALITY

BARBER COLMAN

Aircraft and





AIR VALVES — A wide variety of electrically and pneumatically operated air valves for temperature and pressure-control applications. Butterfly, check, poppet, slide, and automatic drain types.

ACTUATORS — Rotary and linear types featuring a wide range of gear reduc switching and mounting details. Available either as standard units or special d to fit various applications. Designed to applicable military specifications.

New reduced-size electromechanical actuator

another example of how Barber-Colman can help you

put the squeeze on size and weight problems

Assignment: Take the present size actuator (silhouette at left) that operates a 2½" butterfly valve. Squeeze it down as far as you can with no sacrifice in performance. Result: The new Barber-Colman NYLC actuator (inside of silhouette) that reduces volume 50%, weight 55%. And it fulfills all previous high-speed torque requirements for the application. Even with these size-weight reductions, this new actuator meets all applicable military specifications.

Characteristics are as follows: Breakaway torque — 35 lb-in. Continuous load — 25 lb-in. Travel limit — 300°. Temperature range — minus 65° F to plus 250° F. Weight with filter — 0.65 lb. Size — 2⅝" l, 2¼" h, 2⅝" w. (With addition of 9/16" height and 0.25 lb weight, torque can be raised to 75 lb-in. over entire stroke.)

For today's aircraft and missile requirements, Barber-Colman actuators are available in a wide range of sizes and characteristics. Let us work with you on your applications for electromechanical actuators, as well as for air valves, temperature controls, and positioning controls. Consult the Barber-Colman engineering sales office nearest you: Baltimore, Boston, Fort Worth, Los Angeles, Montreal, New York, Rockford, Seattle.

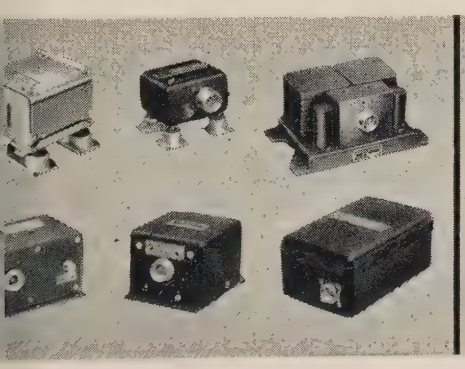
See us at the Aircraft Electrical Society Show . . .
San Diego, Oct. 22-23 — Los Angeles, Oct. 28-30

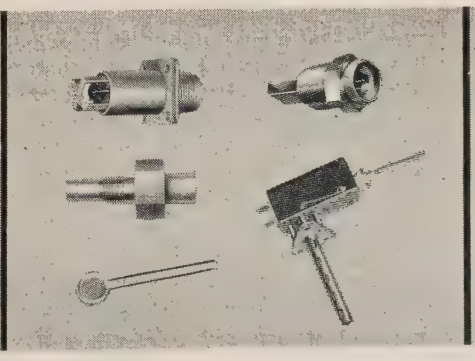
BARBER-COLMAN COMPANY

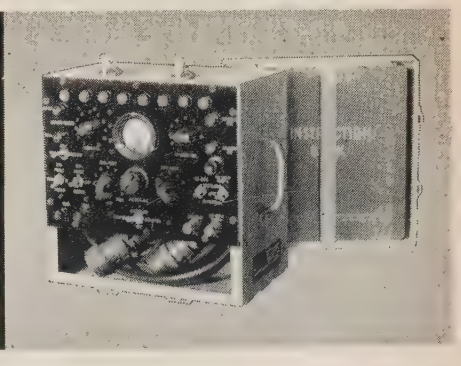
Dept. U, 1423 Rock Street, Rockford, Illinois

Aircraft Controls • Electrical Components • Small Motors • Automatic Controls • Industrial Instruments • Air Distribution Products • Overdoors and Operators • Molded Products • Metal Cutting Tools • Machine Tools • Textile Machinery

Missile Accessories







PERATURE CONTROL AND ITIONING SYSTEMS — Electronic, mag- amplifier, transistor, or relay-controlled ms designed to meet your requirements.

TRANSDUCERS AND THERMOSTATS — Units for sensing compartment, duct, windshield temperatures. CEDAC system senses, controls temperature and/or airflow in ducts.

TEST EQUIPMENT — Compact electrical test units for quickly checking all components of a Barber-Colman control system installed in an aircraft. Special units for checking many electrical systems.

Write in No. 152 on Reader Service Card at start of Product Preview Section

ACCO for Better Values

NEW "NO-MAG"

NON-MAGNETIC AIRCRAFT CABLES

- GOOD THERMAL CHARACTERISTICS
- CORROSION RESISTANT
- HIGH FATIGUE RESISTANCE
- HIGH ABRASION RESISTANCE
- PREFORMED CONSTRUCTION

Eliminates Instrument Interference!

• Just as we expected, many aircraft designers were interested in the recent announcement of our new non-magnetic aircraft cable. If you did not see it, "NO-MAG" has these characteristics:

NON-MAGNETIC PROPERTIES . . . "NO-MAG" cable is made from type 305 stainless steel. It remains non-magnetic after severe cold working —in contrast to standard stainless steel aircraft cable which shows a pronounced increase in magnetism after swaging, wire drawing or similar operations.

This non-magnetic property of "NO-MAG" cable eliminates instrument interference from cable magnetism.

CORROSION RESISTANCE . . . New "NO-MAG" cables have corrosion-resistant qualities similar to, but slightly better than, cables made of standard stainless steel.

GOOD THERMAL CHARACTERISTICS... The thermal expansion characteristics of new "NO-MAG" cable are much closer than those of standard stainless steel or carbon steel cables to the characteristics of aluminum alloys used in aircraft. This greatly simplifies maintaining cable tension under various changes in temperature.

HIGH FATIGUE RESISTANCE . . . Preformed construction and careful processing give new "NO-MAG" cable high fatigue resistance.

HIGH ABRASION RESISTANCE . . . New "NO-MAG" cable shows greater abrasion resistance than standard stainless steel aircraft cables.

TENSILE STRENGTH, while lower than that of stainless and carbon steel, is sufficient to enable replacing these, size for size, with "NO-MAG" on many applications where the characteristics of "NO-MAG" are required.

USE WITH SWAGED TERMINALS . . . Swaged terminals can be applied to standard AN dimensions.

COMPLETE RANGE OF SIZES, CONSTRUCTIONS . . . New "NO-MAG" is furnished in sizes from 1/16" to 1" in all of the standard aircraft cable constructions.

Get the complete story on this new technical development for the aircraft industry. Write today to Detroit office.

Automotive and Aircraft Division
AMERICAN CHAIN & CABLE

ACCO TRADE MARK

601 Stephenson Bldg., Detroit 2
6800 East Acco Street, Los Angeles 22 • Bridgeport 2, Conn.

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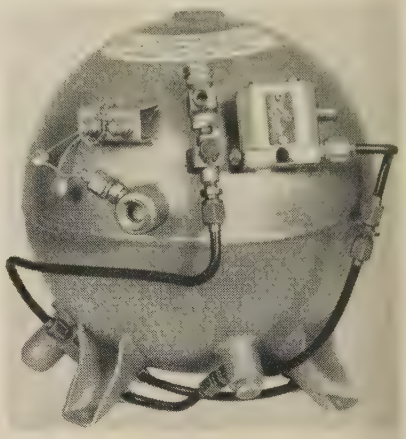
BREATHING CONVERTERS guaranteed one year



Four new liquid oxygen and liquid nitrogen converters are guaranteed for one year against an evaporation loss in excess of the military specification limit. In addition to supplying breathing oxygen to pilots and crew members they can be used for fuel pressurization for missiles and pressurization and fuel inertion systems for many types of aircraft, says **Linde Co., Dept. S/A, 420 Lexington Ave., New York 17, N.Y.**

Two of the converters are made of aluminum and operate at 70 psi. The others, made with a stainless steel inner shell and aluminum outer shell, operate at 300 psi. They meet all MIL-E-5272A vibration tests without deviation. The outstanding design feature claimed for the converters is its special powder-vacuum insulation that minimizes evaporation loss.

Write in No. 282 on Reader Service Card

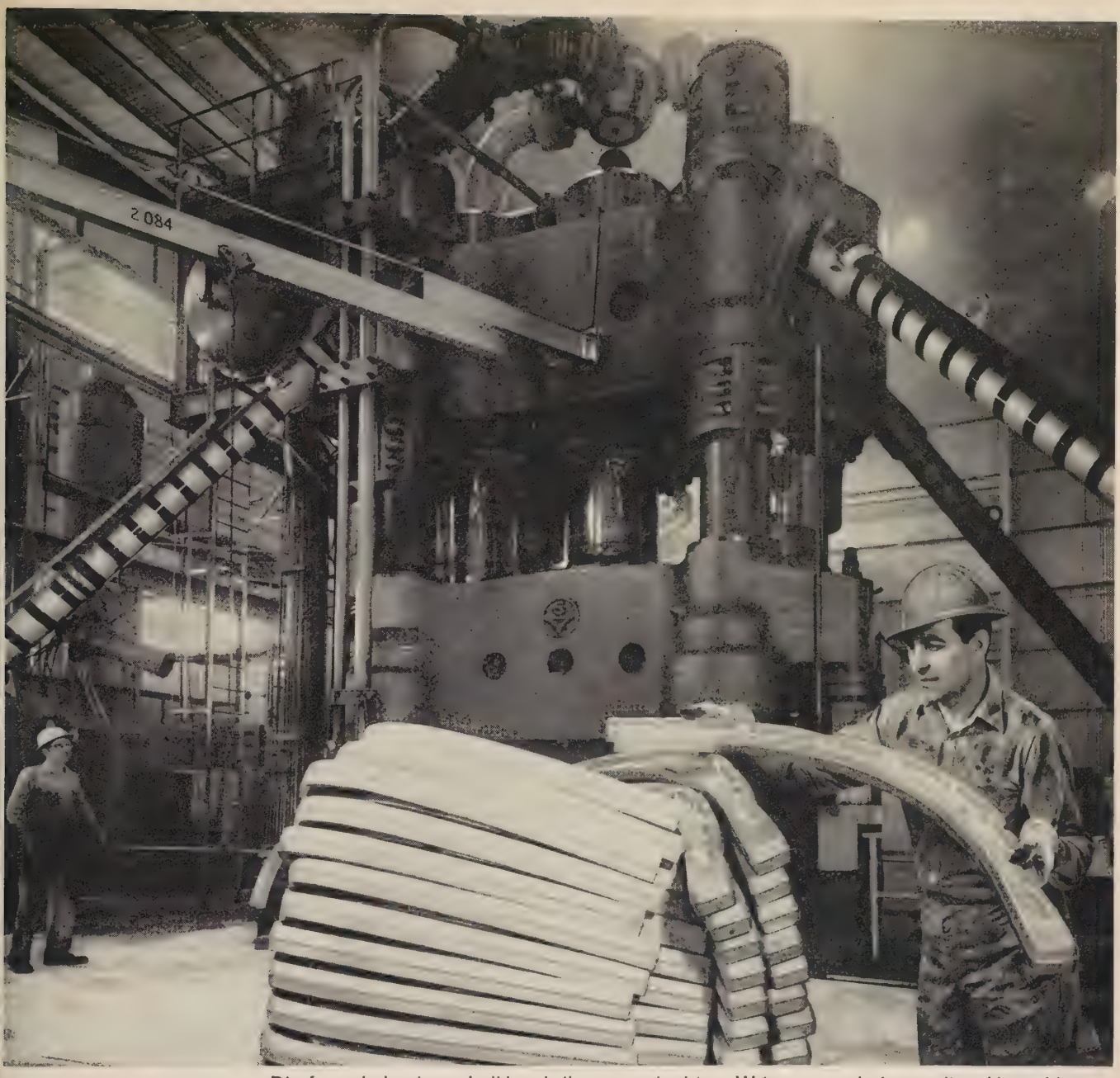
ROCKET MOTOR HEADS made in one piece

Hot-rolled-spun hemispherical rocket motor heads are availabl in a variety of high-strength metals including titanium and sirconium alloys and chrome-moly steels. The parts are formed in one piece without welding. The head and case are continuous and bosses can also be formed integrally with the heads. The result is greater strength and huge material savings, as much as 500 per cent for prototype parts, according to **Titanium Fabricators Inc., Dept. S/A, 3906 Cohasset St., Burbank, Calif.**

Through a new and advanced fabrication technique the hot spinning method replaces normal deep drawing, forging and cold shear spinning processes, thereby reducing tooling costs, it is cla med. Diameters up to three ft are presently available. Larger diameters up to 120 in. can be economically made by this type of equipment, the company says.

Write in No. 283 on Reader Service Card

more on page 226



Die-forged aluminum bulkhead ribs, quenched to —W temper and *stress relieved* by cold processing with simple dies, ready for shipment from Alcoa to Douglas Aircraft at Santa Monica, Calif. The new stress-relief process cuts Douglas' costs in machining time per complete frame.

New... Stress-Relieved DIE Forging Cuts Machining Costs

A DIE-FORGED ALUMINUM component—as the whole airframe industry knows—possesses unique and most praiseworthy virtues. Properly tempered and machined, it is unmatched in an unlimited number of exacting applications.

BUT HEAT TREATING and quenching of any metal leave it "tortured" by internal stresses and strains. Under later machining operations, it is prone to warp and twist. Where tolerances are close, this warping can result in excessive machining problems, excessive and costly corrective operations, serious production delays and even scrapped parts.

UNTIL NOW, these stresses could be minimized only with the greatest difficulty. But today Alcoa is happy to take the wraps off another important "first." As of now, Alcoa has made stress-relieved die forgings as practical as stress-relieved sheet, plate, extrusions and rolled parts—and, three years ago, stress-relieved *hand* forgings which, likewise, were developed by Alcoa.

ALCOA'S PIONEERING APPLICATION of the new stress-relieving technique on fuselage frames for Navy A-4D light bombers is cutting corrective machining operations at Douglas, effecting a big saving on this one part alone. Who can set a limit on the ultimate applications and savings from this development?

IF YOU would like more information, or wish to discuss any aspect of stress relief with an Alcoa sales engineer, please drop us a line. Write to Aluminum Company of America, 2027-J Alcoa Bldg., Pittsburgh 19, Pa.

ALCOA

Your Guide to the Best in Aluminum Value

Write in No. 154 on Reader Service Card at start of Product Preview Section

CAN "MATCHED" SERVO COMPONENTS

IMPROVE SYSTEM PERFORMANCE?

They certainly can! And if performance in your servo system is important, you owe it to yourself to check out the advantages "matched" servo components by Ketay can give you.

For example, Ketay's 105D2V Resolver (designated by the Bureau of Ordnance as Mark 4 Mod 1) trimmed to the TREA 4-100-2 Amplifier gives you a bonus of high performance and interchangeability:

1. The system will be trimmed to ±.02% transformation ratio, with a phase shift tolerance of ±1'.
2. The amplifier will hold linearity to ±.02% from −55° to +100°C.
3. The receiver will achieve .05% conformity to the sine wave, and ±3' interaxis error.

Similar benefits in matched performance can be obtained with system combinations using Ketay synchro transmitters, transformers, receivers, differentials, transistorized servo amplifiers, and servo motors.

But performance is not all you gain. When all or most of your components are from Ketay, broadest technical assistance is assured, and service and spares problems are simplified.

Ketay engineers are working on many advanced environmental and accuracy problems in developing prototype systems. Why not call or write for help in solving your servo component problems?

Ketay matched components:

SYNCHROS
RESOLVERS
POTENTIOMETERS
SERVO MOTORS
TACHOMETERS
SERVO AMPLIFIERS
GYROSCOPES

Catalogues available

NORDEN Division of United Aircraft Corporation

KETAY DEPARTMENT, Commack, Long Island, N.Y.

. . . to make your design ideas work

Does your new product design require an elastomeric material with special characteristics?

LORD can assist you by developing and manufacturing custom elastomeric parts—molded and bonded—to meet the most rigid specifications. Various combinations of the above properties can be incorporated to satisfy unusual designs, special configurations, severe operating conditions.

LORD capabilities include thorough knowledge of all modern elastomers, special skills in creating custom formulations, complete testing and production facilities and exceptional success in solving difficult assignments. Superiority of the LORD rubber-to-metal bond is common knowledge.

For custom-built elastomers to translate your idea into a profitable new product, contact the nearest LORD Field Office or the Main Office, Erie, Pennsylvania.

LORD®
BONDED RUBBER

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"In Canada—Railway & Power Engineering Corporation Limited"

LORD MANUFACTURING COMPANY · ERIE, PA.

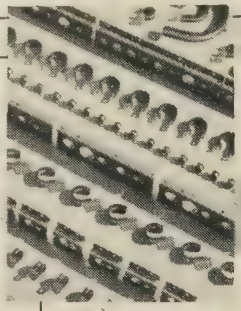
Write in No. 155 on Reader Service Card at start of Product Preview Section

ADEL LINE SUPPORTS

designed for every application

CLAMPS · BLOCKS · HARNESS STRAPS

for military & industrial systems & equipments



They cut maintenance and replacement costs . . . performance and reliability far beyond specifications of any other Line Support.

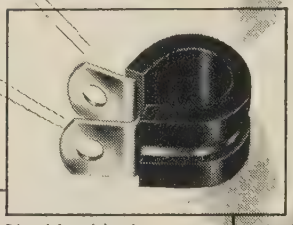
CLAMPS provide cushioned, vibration absorbing support for cables, tubing and piping.

BLOCKS provide resilient support for multiple grouping of lines to eliminate failures.

HARNESS STRAPS embody heat and cold resistant material for temperatures far above +550°F to well below −90°F.

For safety, flexibility, durability and economy SPECIFY ADEL and be certain of getting the best possible service from products that are the result of advanced engineering design and the most modern production techniques.

A COMPLETE LINE . . . SERVICE-FITTED, TESTED AND APPROVED. SPECIFICATIONS ARE AVAILABLE TO AIRCRAFT, MISSILE AND ORIGINAL EQUIPMENT MANUFACTURERS . . . WHAT ARE YOUR REQUIREMENTS?



Reliability **ADEL** PRECISION PRODUCTS

A DIVISION OF GENERAL METALS CORPORATION

Direct inquiries to Huntington Division 1444 Washington Ave., Huntington 4, West Virginia

DISTRICT OFFICES: Burbank • Minneola • Dayton • Wichita • Dallas • Toronto

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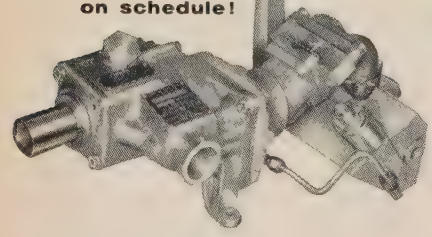
Simple or Complex

FROM JUST A SPEC

MC • DESIGNS
• PRODUCES
• DELIVERS

on schedule!



RELIABLE at every step

In this package MC has condensed many functions:

Solenoid, pilot, two speed 24 GPM Valve, 3000 psi motor, relief, filters, restrictors, timers, bypasses, manual modulating override gears, two output shafts 8000 RPM.

Send your inquiries for hydraulic, pneumatic and fuel components to

M.C. MFG. CO.

P.O. Box 126 • LAKE ORION, MICH.

Write in No. 157 on Reader Service Card

Torque Wrench Adapter

Calculator Slide Rule

Free

Instantly calculates scale conversion factors for adapters of different lever lengths—set it and read it.

Provides automatic selection of proper torque wrench for adapters and/or proper adapters to go with given torque wrenches.

Sent free upon request, compliments of

P.A. STURTEVANT CO.
ADDISON QUALITY ILLINOIS

Write in No. 158 on Reader Service Card

RELIEF VALVE has low pressure drop

This in-line check or relief valve is used in hydraulic, fuel, cryogenic and pneumatic systems. It is suitable for use in pressurizing fuel tanks. It provides forward flow with low pressure drop. Zero internal leakage is maintained against back pressure, says **Aero Supply Mfg. Co., Dept. S/A, Corry, Pa.**

The ½" line size, the valve, #35-2153-008, pressures to 800 psi with 8 psi maximum pressure drop at 2400 lbs./hr fuel flow. Cracking pressure is 5 psi. The weight of the ½" size is .35 lb. and it operates at from −350° F to +350° F.

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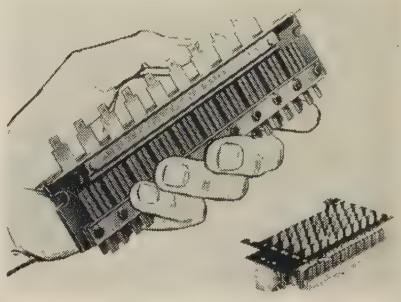
SWITCH has long life



This newly designed Model 7711 Push Button Switch has a mean life of one million operations per station. Each station offers up to four type A contacts rated at 100 ma at 150 Vdc. The switch may be ganged, inter-bussed, cross-interlocked, and is available with lock-out and automatic release solenoids, says **American Electronics Co., Dept. S/A, 2801 37th Ave. NE, Minneapolis 21, Minn.**

The switch may be plated to withstand humidity and salt spray requirements. It is normally supplied with taper-tab or solder terminals.

Write in No. 285 on Reader Service Card

BUSHINGS for use in plastics

A line of drill jig bushings for use in plastics has been developed in two basic types: for embedding in castable materials; for pressing into holes in plastics, wood or other soft or ductile materials. Called Trans-Lok, the bushings cannot be turned in either direction, nor pulled or pushed out of the jig, says **Ex-Cello Corp., Dept. S/A, 1200 Oakman Blvd., Detroit 32, Mich.**

Liner bushings, for use when the jig will outlast the bushing or when more than one operation, such as drilling and reaming, is performed, are available.

Write in No. 286 on Reader Service Card

more on page 228

Jet Engine Hot Spots Torture Superior Super Alloy Tubing

Tubing must not take a permanent set or rupture

Temperatures up to 1800°F torture the Superior Super Alloy Tubing used as fuel lines to spray nozzles and as spray bars for afterburners in a current model jet engine. High oxidation resistance and strength at elevated temperatures are a must. But of even greater importance is the ability of the tubing to resist taking a permanent set or rupturing under the high stresses developed in service.

Parker Aircraft Co.'s Engine Accessories Division, Cleveland, with our cooperation, chose the analyses. Service conditions and fabrication requirements limited them to two: N-155,* incl. approx. 21% chromium, 20% nickel, 20% cobalt, balance iron—plus columbium; Haynes No. 25,† incl. approx. 20% chromium, 10% nickel, 15% tungsten, balance cobalt. Both have excellent oxidation resistance, stress rupture characteristics, high strength at elevated temperatures.

N-155 tubing, as produced by Superior, was selected for the fuel lines because it is amenable to bending and shaping without cracking and is easier to braze. It is also used for the spray bars operating in temperatures under 1300°F because it is easier to drill. When higher temperatures are encountered by spray bars, Haynes No. 25 tubing is used.

Superior Super Alloy Tubing, in a wide range of standard and special analyses, in ODs ranging from .012 through 1.125, is available in both Seamless and WELDRAWN® types. Bulletin 70 describes them in detail. Write us for your copy. Superior Tube Company, 2038 Germantown Ave., Norristown, Pa.

*Reg. U.S. Patent Office, Union Carbide Corp.
†Reg. U.S. Patent Office, Haynes Stellite Co.

Superior Tube

The big name in small tubing
NORRISTOWN, PA.

All analyses .010 in. to ⅝ in. OD—certain analyses in light walls up to 2½ in. OD

West Coast: Pacific Tube Company, Los Angeles, California • FIRST STEEL TUBE MILL IN THE WEST

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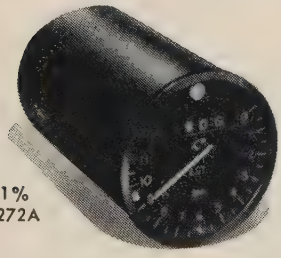
...now taking Lockheed ELECTRA'S *temperature...to 1°C.*



Accuracy 0.1%
Meets MIL-5272A

High accuracy, and easiest *needle pointer plus digital in-line counter readout,* are the principal service features of the BH183 AUTOTEMP™ jet engine temperature indicator.

AUTOTEMP® is designed and produced by the makers of the JETCAL Analyzer®, the only jet engine tester used throughout the world.

The AUTOTEMP is a completely new instrument...a continuous null balance 144-inch slidewire potentiometer combined with a linearizing analog-to-digital converter. Its accuracy is the simple attribute or phenomenon of its novel and basic slidewire potentiometer!

Self-contained...silicon-transistorized, miniaturized, hermetically sealed, servo-driven...the AUTOTEMP'S 3"-diameter case includes a Zener reference, power supply, amplifier, servo motor, cold junction compensation and the 144-inch slidewire and punched tape to linearize thermocouple e.m.f. for exact, counter-type digital readout. The needle pointer indicates in 50°C increments over the 0 to 1200°C full range of the unit.

Full information is contained in our Bulletin BH183 available for the asking!

B & H INSTRUMENT CO., INC.
3479 West Vickery Blvd. • Fort Worth 7, Texas

Sales-Engineering Offices:
ATLANTA, GA., COMPTON, CAL., DAYTON, OHIO., VALLEY STREAM, L.I., N.Y., WICHITA, KAN., TORONTO, ONT. *(George Kelk Ltd.)* MITCHAM, SURREY, ENGLAND *(Bryans Aeroquipment Ltd.)*

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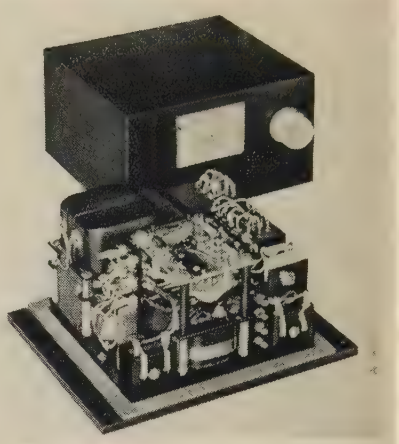
POWER INVERTER converts to 115V



This solid state static power inverter, converts an 18-30 V dc source to an 115 V, 400 cps single phase ac source. It is said to have a life expectancy of 20,000 hours under continuous operation. It has no moving parts, functions noiselessly, and contains no vacuum tubes. It has a vibration range of ten to 2,000 cycles, can withstand high shock to 30 times its weight, and will not spark at any altitude, says **Magnetic Amplifiers, Inc., Dept. S/A, 632 Tinton Avenue, New York 55, N.Y.**

Built to MIL-E-5400 and E-5272, the inverter includes other features as: regulation of 1½ per cent for load variations from no-load to full-load; power factor of —0.5 to +0.5; max distortion of five per cent; operation in ambient temperatures from —55 to +71 deg C. It measures four inches high, six inches wide, and six inches long. It weighs ten pounds.

Write in No. 287 on Reader Service Card

PUMP AND MOTOR for nose antenna

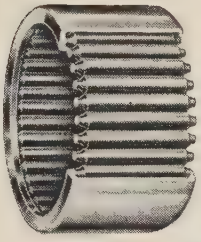
This high pressure pump and motor assembly, Model 1213-HBG-221, for driving the nose antenna in a missile features high operational speed, permitting light-package manifold construction and the elimination of plumbing connections. Over-all pump and motor efficiency is in excess of 50 per cent, says **Eastern Industries, Inc., Dept. S/A, Hamden, Conn.**

Performance characteristics show 4.0 gpm at 650 psi, using MIL-O-5606 fluid. The pump is driven by 11,000 rpm motor; voltage supply is 200 V, 400 cycles, three phase; power requirements are 2220 W and the power factor is 0.79. Operating ambient temperature range —65 to +165 deg F. Combined weight of pump and motor is eight pounds.

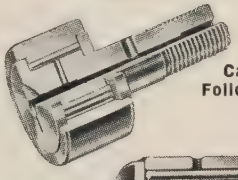
Write in No. 288 on Reader Service Card

more on page 230

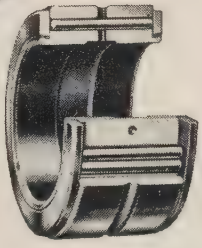
In the Marines' newest "skyhooks," Kaman HOK-1 Helicopters, Torrington Cam Followers and Type DC Needle Bearings are used in the control system for compactness, and Type NBC Needle Bearings are used in rotor hubs for high load capacity.



Needle Bearings



Cam Followers



TYPE NBC

Helping put the lift in "skyhook"

In helicopters, lower weight means greater load lifting ability. Kaman Aircraft Corporation achieves this with extensive use of Torrington Needle Bearings in HOK-1 Helicopters.

The nine Needle Bearing Cam Followers and 22 Type DC Needle Bearings in the control system provide high capacity in minimum space. They also allow for the compactness and light weight of other adjacent components. Six NBC Needle Bearings provide high load capacity in the lead-lag pivots and the teeter pivot where dependable anti-friction operation is essential. These high capacity bearings support the helicopter.

Torrington Needle Bearings have found extensive use in modern aircraft where minimum weight and maximum capacity are so vital. Torrington offers engineering assistance based on its extensive experience with aircraft applications to help you improve the performance and reliability of your equipment. **The Torrington Company, Torrington, Conn.—and South Bend 21, Ind.**

TORRINGTON BEARINGS

District Offices and Distributors in Principal Cities of United States and Canada

NEEDLE • SPHERICAL ROLLER • TAPERED ROLLER • CYLINDRICAL ROLLER • NEEDLE ROLLERS • BALL • THRUST

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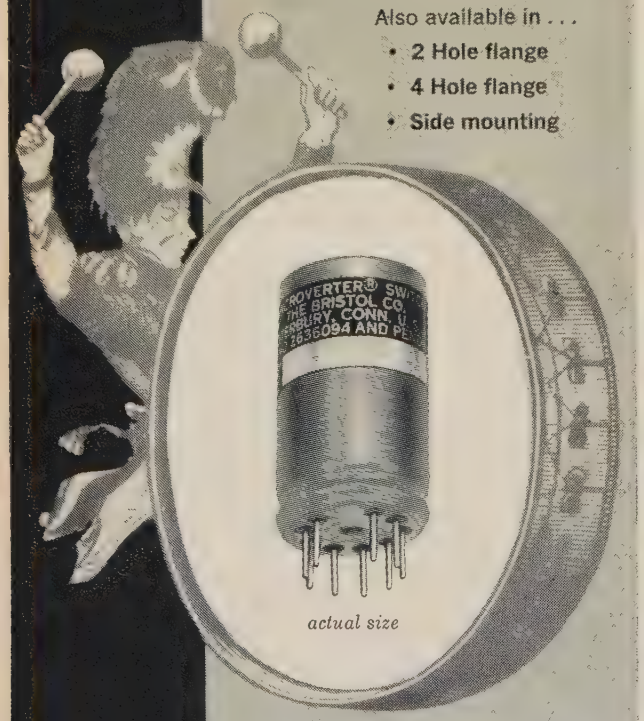
BRISTOL
miniature
DPDT
chopper
CL430 Series

• Excellent tracking
• Miniature size
• Phase stability with temperature
• High vibration rating
• High contact rating
• Long life • Reliability
• Versatility

Also available in . . .
• 2 Hole flange
• 4 Hole flange
• Side mounting



actual size

For complete specifications, write:
Aircraft Components Division,
The Bristol Co.,
150 Bristol Road,
Waterbury 20, Conn. 9.19

BRISTOL FINE PRECISION INSTRUMENTS FOR SEVENTY YEARS

Write in No. 162 on Reader Service Card

MOTOR
has high start torque

This 400 cycle motor has exceptionally high starting torque and low starting current in a compact motor for a wide variety of aeronautical applications. It is designed to operate off type I power per Mil-E-7894 and to operate continuously at ambient temperatures per curve I of MS33543—full load at 50,000 ft.; 60% full load at 65,000 ft., says **Eicor, Dept. S/A, 4057 W. North Ave., Chicago, Ill.**

The 5 hp motor is rated at 7600 rpm, weighs 28.5 lbs., has starting current of 290% at full load and starting torque of 160% (par. 4.5.9.2 Mil-M-7969a).

Write in No. 289 on Reader Service Card

PIPE CONNECTOR
allows misalignment

This lightweight flexible coupling provides positive seal and grip under misalignment conditions and also permits tubing gaps to .190. This model PC-4 has knurled nuts to permit hand installation on beaded or flanged type tubing and is especially recommended for the rapid joining of tubing in confined areas where the use of wrenches is prohibited, says **Flight Refueling, Inc., Dept. S/A, Box 1701, Baltimore 3, Md.**

A safety wire retains the pipe connector after installation. Adaptable to many fluids, in sizes from ¾″ to 4½″, the pipe connector has been fully tested to Mil-C-25014.

Write in No. 290 on Reader Service Card

SWITCH
for up to 1500 deg F

This switch, the Thyrastat, is a temperature-sensitive switch for missile and aircraft applications. It is hermetically sealed, single-shot switches available in normally open and normally closed, single pole types. They are preset for activating temperatures from +113 to +1500 deg F, says **Thermocal, Inc., Dept. S/A, 1629 Colorado St., Santa Monica, Calif.**

The electrical characteristics are: switch, four, ten, 50, 100, or 300 amp; contact resistance, less than 0.3 ohm; hypot, 1500 V rms at 60 cycles at sea level; and insulation resistance, 200 megohms min (before and after firing). Its environmental characteristics are: altitude, unlimited; humidity, MIL-E-5272B(USAF); shock, 250 g's, two to four millisecond duration; and, vibration, two to 20,000 cps at 40 g's.

Write in No. 291 on Reader Service Card

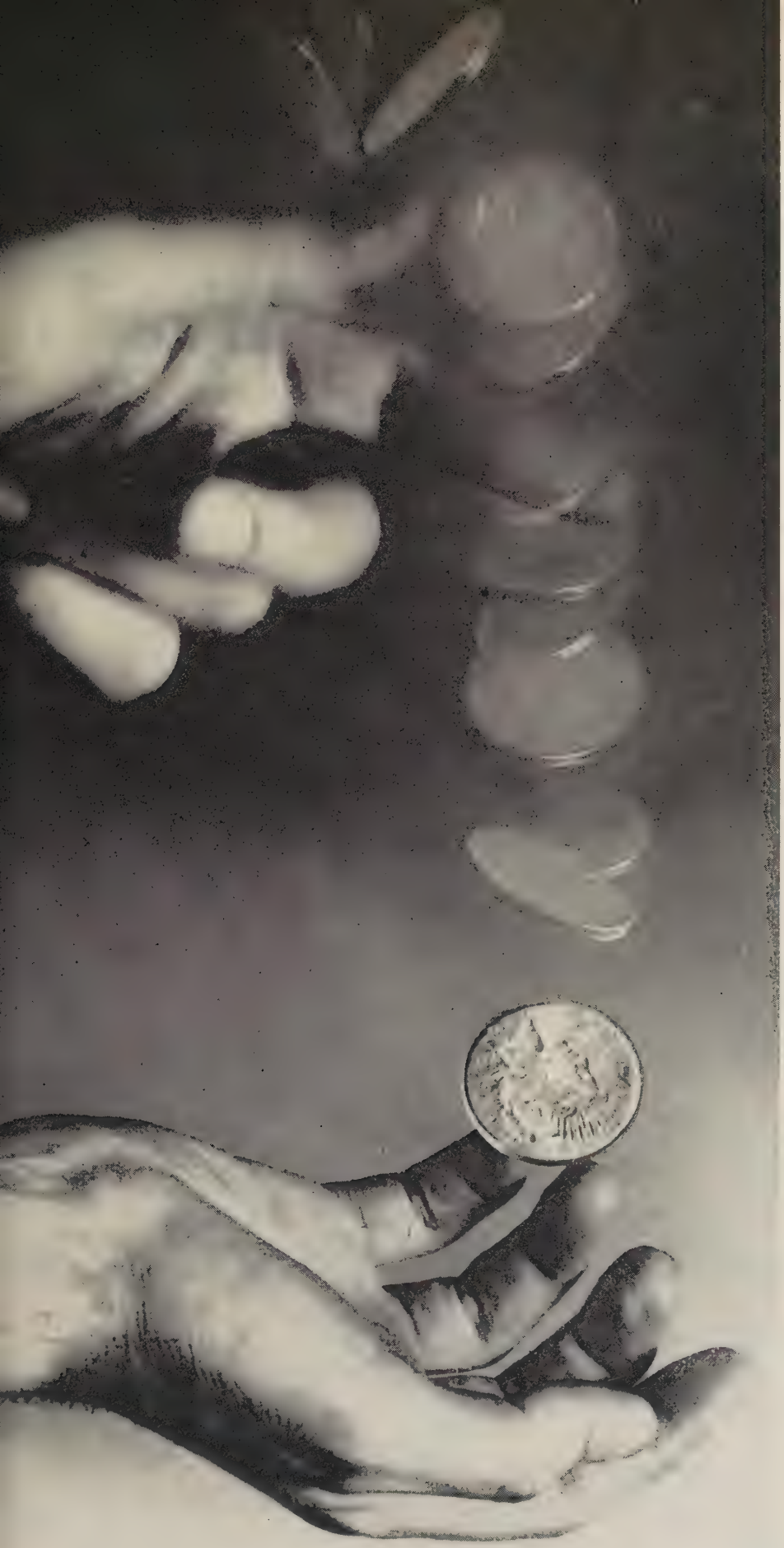
PUMPING PACKAGE
weighs two pounds

This fuel and lubricating oil pumping and fuel control system package for small turbines in a single unit weighing two pounds. The system is to be pad mounted on the turbine with a drive speed of 24,000 rpm. Lubricating oil delivery is through the drive shaft. The fuel system includes gear type constant displacement fuel pump, fuel pressure regulating valve, fuel inlet check valve for starting, magnetic fuel filter and a model E/FCV-100, type 200 electrically operated fuel control servo valve, says **Eastern Industries, Inc., Dept. S/A, 100 Skiff St., Hamden, Conn.**

The lubricating oil system has a gear type constant displacement lubricating oil pump, lubricating oil pressure regulating valve, lubricating oil—40 micron filter and a lubricating oil filter bypass valve.

Write in No. 292 on Reader Service Card

more on page 232



He took the luck out of heads or tails

This AMF engineer had a delicate problem: to accomplish the separation of the expended stages of a multi-stage rocket. If separation occurs too soon, thrust in the nearly burned out stage may exceed the aerodynamic drag, the tail overtakes the head, and...boom. A million dollar collision and no insurance.

His solution: An acceleration switch that turns the burned out stage loose at the right split second ...a switch that makes rockets think for themselves.

His switch is compact. It is designed to work in any missile at any range with any payload. It is ingeniously simple in conception, design, and operation. A spring is attached to a free swinging hammer, the spring force acting to pull the hammer against the contact plate. At calibration the spring can be set to oppose any G from 1 to 100. When the missile is launched, the hammer is held back by the acceleration forces until the stage decays to the desired separation G. When the spring force overcomes the forces of acceleration, the hammer comes forward, strikes the contact plate, and the circuit required to make separation is closed automatically. No guesswork, no luck, no *collision.*

Single Command Concept

This simple solution to a tricky problem reflects the resourcefulness of AMF people.

AMF people are organized in a *single operational unit* offering a wide range of engineering and production capabilities. Its purpose: To accept assignments at any stage from concept through development, production, and service training... and to complete them faster...in

- *Ground Support Equipment*
- *Weapon Systems*
- *Undersea Warfare*
- *Radar*
- *Automatic Handling & Processing*
- *Range Instrumentation*
- *Space Environment Equipment*
- *Nuclear Research & Development*

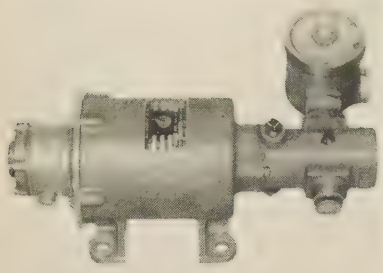
GOVERNMENT PRODUCTS GROUP, AMF Building, 261 Madison Avenue, New York 16, N. Y.

AMF

ngineering and manufacturing AMF has ingenuity you can use... **AMERICAN MACHINE & FOUNDRY COMPANY**

Write in No. 163 on Reader Service Card

COMBINATION PUMP for pressure and vacuum



This combination vacuum and pressure pump, Model RR18380, primarily for pre-flight testing of missile instruments consists of vane type dry air pressure pump and an oil wetted rotary vane type vacuum pump, mounted at opposite ends of an electric drive motor. The oiler, using silicone oil can be positioned to allow the complete unit to be mounted in any position from zero to 90 deg. The unit will operate satisfactorily in ambient temperatures from —65 to +130 deg F, says **Lear-Romec Div., Lear, Inc., Dept. S/A, Elyria, Ohio.**

The pressure pump will deliver 700 cipm of free air at 15 psi gage or it can be furnished with a piston pump for pressures up to 65 psi gage. The vacuum pump has an ultimate vacuum of 0.20 in. Hg absolute or 1200 cipm free flow with no vacuum. The electric motor is ¼ hp at 3600 rpm, 200 Vac 400 cycle.

Write in No. 293 on Reader Service Card

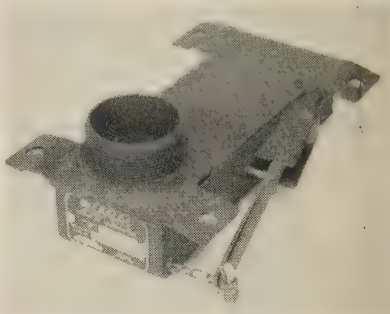
GYROSCOPE is vertical type

This new vertical gyroscope, N32-00A, designed especially for drone aircraft applications is a two-axis, cageable model constructed of welded, wrought, non-magnetic stainless steel to withstand shocks and vibration. It conforms to MIL-C-7436A, Control, Roll and Pitfh, Electrically Driven, Vertical Gyro Operated, Type K7, says **Electronics Div., Iron Fireman Mfg. Co., Dept. S/A, 2838 S. E. Ninth Ave., Portland, 2, Ore.**

The gyro is maintained in vertical position by the precessive action of air jets controlled by gravity sensing vanes located on the top of the inner gimbal. To provide air for erection a blower is attached to the rotor motor. Potentiometers are provided on pitch and roll axis to indicate displacements from vertical, and case cageing is accomplished by an external manual control.

Write in No. 294 on Reader Service Card

IMPULSE GENERATOR for launching equipment



This Impulse Generator, the Microloc 10450, creates an electrical pulse suitable for initiating explosives, etc., after the separation or launcing of a device, such as a bomb, from a parent vehicle, or stored energy in any form, says **Microloc Corp., Dept. S/A, 5808 Marilyn Ave., Culver City, Calif.**

The design provides that the travel before initiation can be accurately varied from zero inches to six feet by a simple field adjustment. The generator claims high reliability, long service life, and is said to be virtually immune to environments encountered in airborne and ordnance systems.

Write in No. 295 on Reader Service Card

more on page 234

THE TREND IN DRAFTING ROOMS THROUGHOUT THE WORLD IS TOWARD IMPERIAL, THE WORLD'S FINEST TRACING CLOTH

Write in No. 164 on Reader Service Card

this NO-COST TEST OFFER has CONVINCED thousands

. . . send for YOUR FREE "TEST CAN" of C-5 "hi-temp" ANTI-SEIZE THREAD COMPOUND!

For one hunderd and one aircraft uses such as slip joints, spark plugs, manifold studs, turbo blowers, jet engines, etc.

Try C-5 and see why leading aircraft manufacturers and thousands of industrial users have made it a part of their regular preventative maintenance program.

fel-pro C5 "HIGH-TEMP"

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- ✓ Ends Seizing and Galling even up to 1800°F.
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ANTI-SEIZE THREAD COMPOUND

C-5's exclusive colloidal copper formula separates mating metal threads and surfaces with cushioning, protective copper plating. C-5 prevents galvanic action and eliminates pitting even when dissimilar metals join. On mating metal surfaces, C-5 saves gaskets and countless man hours.

WRITE TODAY . . . For Your FREE Test Sample Can of C-5.

FELT PRODUCTS MFG. CO.
Dept. 52, P.O. Box 8609
Chicago 80, Ill.

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FIAT G 91 T

A NEW FIAT JET-TRAINER

(*Bristol Orpheus 803 engine*)

- This Jet-Trainer is derived from the G 91 lightweight tactical fighter, winner of the NATO competition, and is expressly designed for advanced training up to supersonic speeds.
- The ability to operate from short, semi-prepared or grass runways, the safety of evolutions performed at low speeds, the great responsiveness, the simplicity and low cost which are peculiar to the single seater version, are all to be found in the two-seater type.

FIAT - AVIATION DIVISION

200, Corso Giovanni Agnelli - TURIN (Italy)

Write in No. 166 on Reader Service Card at start of Product Preview Section

SOUTHWEST

"Monoball"®

SELF-ALIGNING BEARINGS

ROD END TYPES

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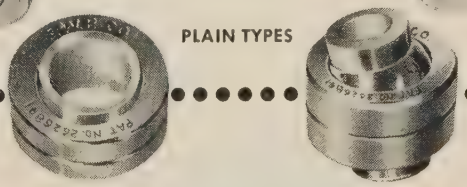
PLAIN TYPES



CHARACTERISTICS

	ANALYSIS	RECOMMENDED USE
1	Stainless Steel Ball and Race	For types operating under high temperature (800-1200 degrees F.).
2	Chrome Alloy Steel Ball and Race	For types operating under high radial ultimate loads (3000-893,000 lbs.).
3	Bronze Race and Chrome Steel Ball	For types operating under normal loads with minimum friction requirements.

Thousands in use. Backed by years of service life. Wide variety of Plain Types in bore sizes 3/16" to 6" Dia. Rod end types in similar size range with externally or internally threaded shanks. Our Engineers welcome an opportunity of studying individual requirements and prescribing a type or types which will serve under your demanding conditions. Southwest can design special types to fit individual specifications. As a result of thorough study of different operating conditions, various steel alloys have been used to meet specific needs. Write for Engineering Manual No. 551. Address Dept. S/A 59.

SOUTHWEST PRODUCTS CO.
1705 SO. MOUNTAIN AVE., MONROVIA, CALIFORNIA

Write in No. 167 on Reader Service Card

FREON URETHANES have low K

A development in the area of Freon expanded urethane foams for the low temperature insulation field is said to be a "radically" new "Lockfoam" polymer that exhibits "one-half the thermal conductivity (K factor) of the polymers used in existing foams." Freon retention and a closed cell content is said to be in excess of 95%. Physical properties of the foams are slightly higher with "virtually no loss of K factor due to ageing," according to **Nopco Chemical Co., Plastic Division, Dept. S/A, North Arlington, N. J.**

Used in conjunction with Freon, produces K values of about .1, and, because of its structure, retains the Freon.

Write in No. 296 on Reader Service Card

FLOW SENSOR cuts wear and error

This Fluid Bearing Flow Sensor determines fluid velocity in a constant area passage containing a spinning turbine rotor supported entirely by a fluid film serving as a bearing. Since the rotor floats entirely on the fluid film, wear and error effects from either radial or thrust friction are said to be overcome. This design provides wider rangeability, better reproducibility and unlimited life without sacrificing other characteristics of turbine-type flow sensors, says **Waugh Engineering Co., Dept. S/A, 7842 Burnet Ave., Van Nuys, Calif.**

Ranges of ten to one are obtainable with this instrument with an accuracy of ¼ per cent of the actual flow rate. The unit is claimed to be virtually indestructible and cannot be damaged by continuous over-ranging up to several times the nominal limit.

Write in No. 297 on Reader Service Card

PRESSED GLASS seals to stee

A pressed and sintered glass that can be sealed directly to stainless steel is composed of multiform glasses made from minute glass particles pressed to shape and then fired at high temperatures. The Code 9019 Multiform glass can be hermetically fused to 430 Ti and 446 stainless in a low-compression type seal, says **Corning Glass Works, Dept. S/A, Corning, N. Y.**

The process permits intricate shapes, holes and small radii to be formed economically in glass. The parts retain the thermal endurance, corrosion resistance and dielectric strength of the parent glass, it is said.

Write in No. 298 on Reader Service Card

POWER RELAY is rugged

A new general purpose power relay, type U, is said to be ruggedly built with single coil construction, employing box type magnetic field. Movable contact springs are mounted on molded phenolic insulating bars, providing positive contact alignment. Contacts of ¼ in. diameter are available in either silver or silver cadmium oxide, rated singly at ten to 25 amperes, 110 V ac, non-inductive. Available contact forms 1C to 5C. Maximum contact pressures 35 grams each, says **Comar Electric Co., Dept. S/A, 3349 Addison St., Chicago 12, Ill.**

Dc relays incorporate use of high quality iron annealed for maximum efficiency. Ac relays have silicon iron parts with copper shading washers.

Write in No. 299 on Reader Service Card

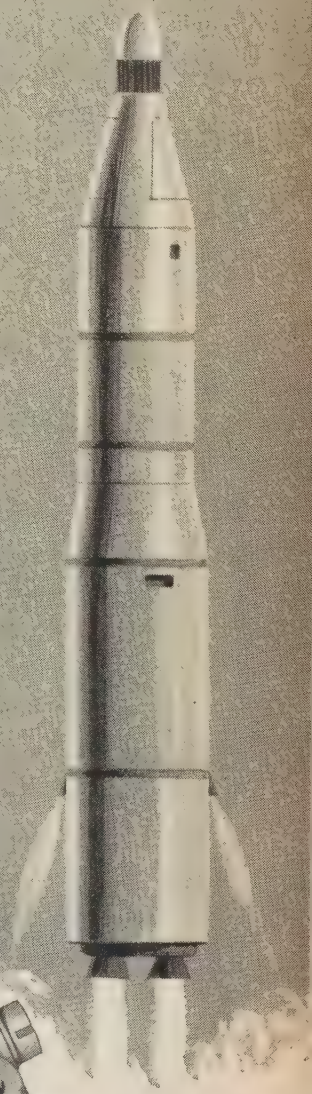
more on page 236

Write in No. 168 on Reader Service Card

BEING INTEGRATED INTO TOMORROW'S AIRCRAFT AND MISSILE SYSTEMS

NEW VICKERS®

Variable Displacement Hydraulic Pumps with MAXIMUM HP/LB RATIO

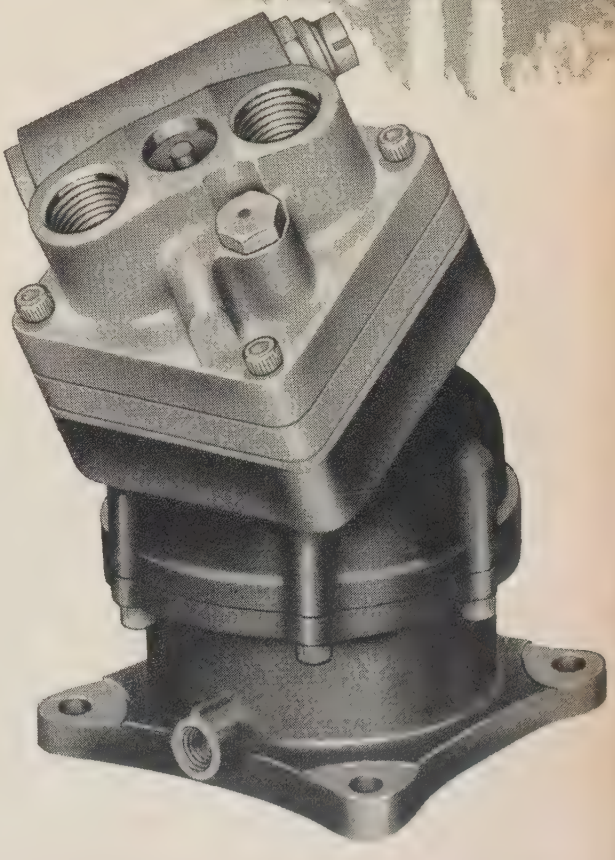


Model Series	Displacement cu. in./rev.	RPM		Weight lb.	HP/LB*	
		Limited Life	Rated		Limited Life	Rated
PV006	.095	18,200	12,500	2.8	4.55	3.12
PV012	.188	14,500	10,000	4.5	4.45	3.06
PV024	.367	11,600	8,000	6.9	4.53	3.13
PV039	.600	10,000	8,000	10.2	4.33	3.46
PV062	.950	8,900	7,000	14.0	4.44	3.49
PV104	1.600	7,500	5,800	19.0	4.65	3.59
PV163	2.500	6,500	5,100	26.0	4.60	3.60

his is hydraulic output horsepower at 3000 psi

The above table is important to anyone concerned with the selection of draulic pumps for future air or space vehicles. Note particularly the rsepower-to-weight ratios for both rated and limited life speeds. These e the highest known available at this time.

But highest hp/lb is only one of many advantages offered you by the w Vickers advanced design variable displacement pumps. Developed to et the requirements of the new MIL-P-19692 specification, this new series s volumetric efficiencies of 96% to 98% over a pressure range of 500 to 00 psi . . . and has 4000 psi continuous operation capabilities. These mps have faster response and improved contamination resistance; they ve practically the same envelope as constant displacement units of equal tput. The first five sizes are now being integrated into advanced aircraft d missile systems; the two larger sizes are in the development stage. rite for Bulletin A-5233 for additional information.



Variable Hydraulic Motors using the Advanced Design Series concept are now under development.

VICKERS INCORPORATED

DIVISION OF SPERRY RAND CORPORATION

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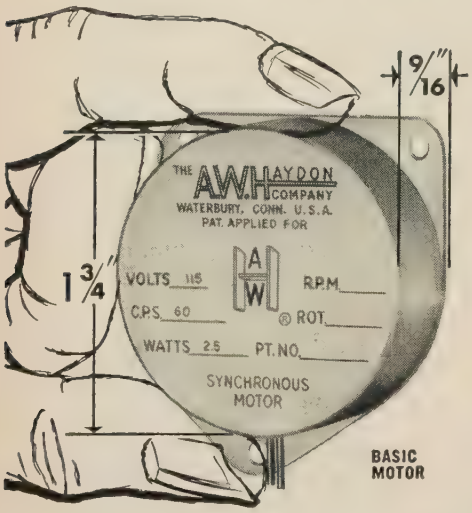
RSEAS REPRESENTATIVE: The Sperry Gyroscope Co., Ltd.—Great West Road, Brentford, Middx., England

gineers and Builders of Fluid Power Equipment Since 1921

ANOTHER FIRST...

THE ONLY *Electro-Reliable* A.C. TIMING MOTOR



BASIC MOTOR

Thinner...
Quieter...
More Reliable...
More Versatile

FINGER-THIN...

Only 9/16 Inches Short... Only 1¾ Inches in Diameter... very compact... reduces the size of your equipment.

WHISPER-QUIET...

Strictly an electrical motor... practically noiseless... no rattling of gears or ratchets.

HIGH TORQUE...

¼ oz. inch at the rotor with instantaneous start and stop... requires only 2½ watts... can replace larger motors in recorders, controls and telemetering equipment.

HIGHEST RELIABILITY...

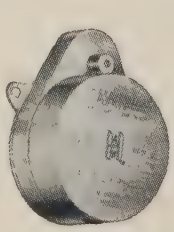
Longer life... no one-way gears or ratchets to fail... provides millions of operations without any trouble.

SPECIFICATIONS

Standard Voltage Ratings: 6, 12, 24, 115, 230 Volts
Frequency: 60 CPS Standard
25, 50 CPS Available
Power Input: 2.5 Watts Maximum (60 CPS)

BASIC MOTOR
Weight: 4 ounces
Speed: 300 RPM
Torque: ¼ oz-in.
Length: 9/16 inch

WITH INTEGRAL GEAR TRAIN
Weight: 5 ounces
Speed: 300 RPM to 1/6 RPH
Torque: 30 oz.-in. @ 1 RPM
Length: ⅞ inch



WITH INTEGRAL GEAR TRAIN

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Send For Special Illustrated Bulletin AWH MO-806

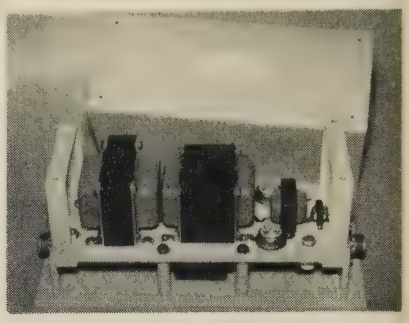
The A.W. HAYDON *Company*

223 NORTH ELM STREET, WATERBURY 20, CONNECTICUT

Custom Design & Manufacture Of Electronic And Electro-Mechanical Timing Devices

Write in No. 169 on Reader Service Card at start of Product Preview Section

SERVO AMPLIFIER is electrically rugged



The Model AS-20 servo amplifier is designed for critical heavy-industry and automation applications. Completely tubeless and using semiconductor circuitry throughout, it is mechanically and electrically ruggedized. An input circuit will operate unharmed with continuous input overvoltage of 2500 per cent. It will not be damaged by loss of load, even when driven by the maximum rated input signal, says **Di/An Controls, Inc., Dept. S/A, 40 Leon St., Boston 15, Mass.**

The electrical characteristics of the amplifier at 60 cps are as follows: input impedance, 20,000 ohms; output impedance, (750 +j 250) ohms; voltage gain, 57; power gain, 50 db; over-all phase shift, less than ten degrees; input voltage, 2.0V rms (for full 115V rms output), up to 50V rms without damage; output power, 20W max. It is 4x5x11 in. and weighs ten pounds. It will operate at full ratings from —55 to +55 deg C, in humidity of 0-100 per cent at 55 deg C. A militarized version is available to meet MIL-E-5400.

Write in No. 300 on Reader Service Card

ALTIMETER has unusual design

Two mechanically separate but electrically connected components form the heart of an unusual altimeter, says **Kelvin Hughes (Aviation), Ltd., Dept. S/A, Winchester Rd., Basingstoke, Hampshire, England.** Pressure measurement is obtained from the output of a force balance unit after it has been mechanically converted from pressure to height and then corrected for position error by means of a computing circuit.

A synchro transmission is then used to feed the corrected height output to the presentation unit. Examples of the system's total error, based on PE information obtained to an accuracy of plus or minus ten ft, are: zero ft, ±20 ft; 40,000 ft, ±40 ft; and 70,000 ft, ±160 ft. The device's computer component weighs about six lb, less mounts, and the presentation unit weighs about two lb.

Write in No. 301 on Reader Service Card

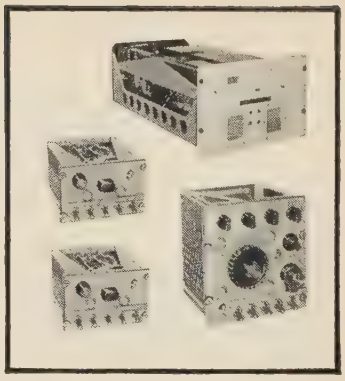
more on page 240

COMMUNICATIONS...

Radio Set AN/ARC-57 . . . designed and developed by *The Magnavox Company*, in conjunction with the Air Force, is an essential UHF communications system, providing the utmost in performance and reliability for the CONVAIR B-58.

It clearly demonstrates *The Magnavox Company's* ability to produce and work as a prime contractor on a complex weapons system.

MAGNAVOX capabilities are in The Fields Of Airborne Radar, ASW, Communications, Navigation Equipments, Fusing and Data Handling . . . your inquiries are invited.



PRODUCTS
THAT SPEAK FOR
THEMSELVES

Magnavox

THE MAGNAVOX CO. • DEPT. 105 • *Government and Industrial Division* • FORT WAYNE, IND.

Write in No. 170 on Reader Service Card at start of Product Preview Section

NEW HIGHER PERFORMANCE FOR FORMCHROME* SPRAGS

On over-running clutch applications, Formsprag clutches have always provided greatest torque capacity for size and weight, no measurable backlash, extreme precision and long trouble-free life. Now! With newly designed Formchrome sprags, the best over-running clutches provide users with even higher performance.

Here's why! The new Formchrome sprags are made of hardened high carbon alloy steel with chromium diffused into the surface to form a chromium-carbide alloy. Thus, the sprag is corrosion resistant, and has high hardness and abrasion resistance similar to tungsten carbides. Result—sprag geometry is retained over a longer period and clutches can be used on higher over-running speeds. The Formchrome sprag is exclusive with Formsprag—no other clutch manufacturer can offer you its performance advantages.

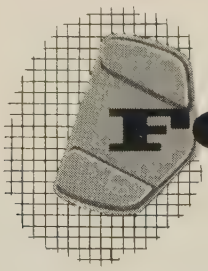
Typical of the higher performance users can now receive from Formsprag clutches is this specific example: A Formsprag clutch using Formchrome sprags was installed in the reaction member of a torque converter and a competitive clutch in another. The competitive clutch showed excessive wear after the equivalent of one year of operation. The Formsprag clutch was run 50% longer and still showed only negligible wear.

There is a Formsprag clutch for every application—from business machines to aircraft. Standard clutches cover a wide range of uses and are described in the Formsprag Catalog . . . send for your free copy. However, to meet unusual requirements, Formsprag engineers will modify a standard clutch or design a special—send your application details.

FORMSPRAG COMPANY
23597 Hoover Road, Dept. 102
Warren (Detroit), Michigan

In Canada: Renold Chains Canada, Limited
In United Kingdom: Renold Chains, Limited
Distributors in Principal Cities

*Formchrome sprags are produced under a patented process. The use of this process in the manufacture of over-running clutches is exclusive with Formsprag.



FORMSPRAG CLUTCHES

World's Largest Exclusive Manufacturer of Over-running Clutches

TYPICAL APPLICATIONS WHERE FORMCHROME SPRAGS HAVE PROVEN SUPERIOR PERFORMANCE

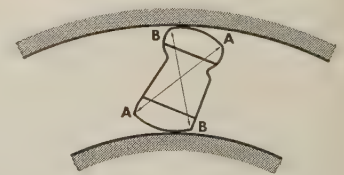
1. Used in operating submarine missile (Regulus II), Formsprag clutch allows alternator to over-run the hydraulic driving mechanism.

2. Backstop clutch on belt conveyor handling bauxite ore is subjected to higher over-running speed, extreme abrasive dust and hot weather—has been in operation a year.

3. Starter clutch for aircraft ground support system allows high-speed gas turbine to over-run starter unit.

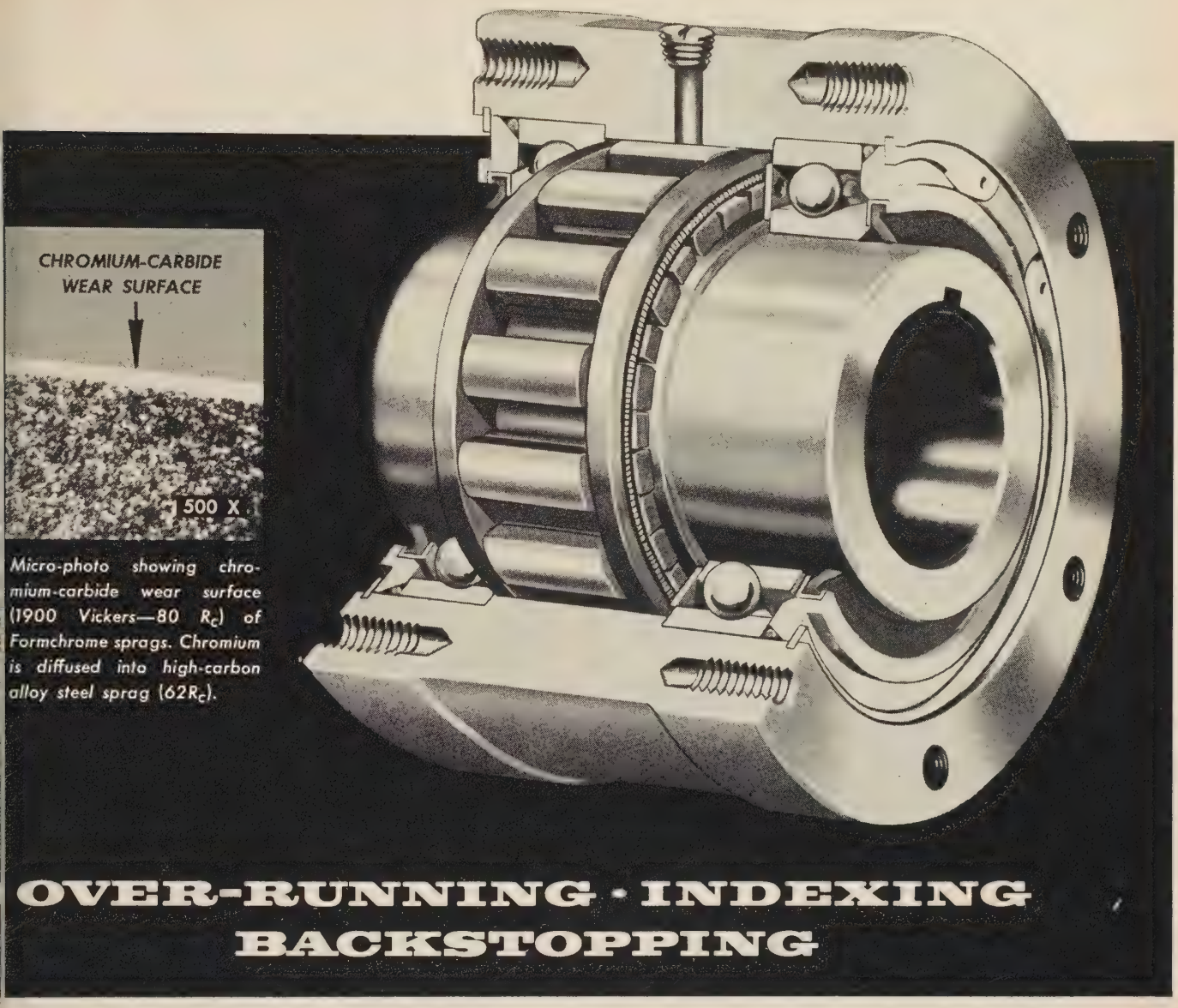
For additional information on how Formchrome sprags assure better performing clutches, write for technical paper "Formchrome Sprags".

HERE'S



The Formsprag clutch consists of a full complement of shaped sprags, or wedges, located between concentric inner and outer races. Power is transmitted from one race to the other by the wedging action of the sprags. Each sprag is so shaped that dimension AA is greater than BB. Rotation of one race in the "driving" direction causes the sprags to wedge, transmitting torque in full from one race to the other.

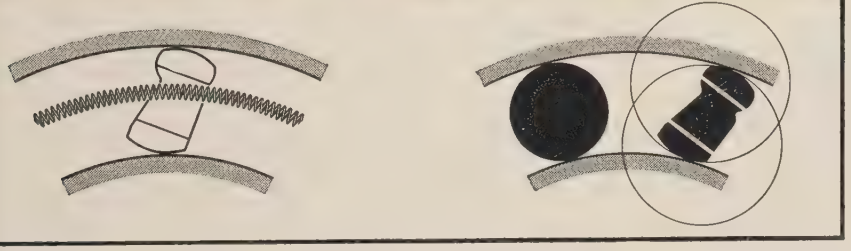
FORMSPRAG OVER-RUNNING CLUTCHES WITH



Micro-photo showing chromium-carbide wear surface (1900 Vickers—80 R_c) of Formchrome sprags. Chromium is diffused into high-carbon alloy steel sprag (62R_c).

OVER-RUNNING · INDEXING BACKSTOPPING

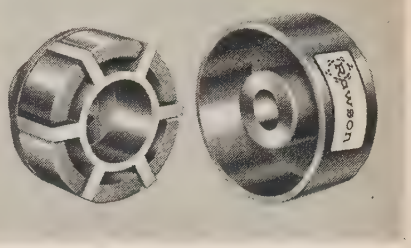
HOW IT WORKS



An expanding coil spring keeps the sprags in light contact with both inner and outer races. There is thus no lost motion, the driving torque being instantaneously transmitted between races. The Formsprag Clutch is so designed that it will transmit a greater torque in relation to its size and weight, than any other comparable type of clutch . . . specify Formsprag on over-running, back-stopping and indexing applications.

Forcing a ball or roller into a curved, wedged space is an old over-running clutch principle. The sprag is, in effect, a "roller" of increased diameter with greater contact surface in a given annular space. Formsprag Clutches engage at constantly changing contact points. Clutch life is prolonged and backlash eliminated. Also, with the inclined surfaces discarded, more sprags can be inserted to increase torque capacity.

RAWSON FOR NO-LOAD STARTS



Specify Rawson Automatic Centrifugal Clutches and Clutch Couplings. They protect the prime mover, eliminate need for costly reduced voltage starting equipment, permit use of less expensive smaller motors to start high inertia loads. Completely automatic and entirely mechanical in operation. Rawson clutches provide full overload protection, never need adjustment. Write for the new Rawson Clutch Catalog now.

Write in No. 171 on Reader Service Card at start of Product Preview Section

Here is a man you should know, he's a

DELAVAN FUEL INJECTOR SPECIALIST

His name is Roger W. Tate. He did his doctoral research in the field of pressure atomization at the University of Wisconsin, has taught reaction kinetics, and worked on process improvements for petroleum refining.

Dr. Tate is Director of Research at Delavan. He has developed many atomizing devices and uniquely accurate test equipment for Delavan. He is widely known for his research on spray analysis and fuel injection.

Specialized talent like Dr. Tate's is the main reason for Delavan's leadership in fuel injection. If fluid metering and atomization are part of your product, take advantage of Delavan's specialized experience and ability to deliver aircraft quality. Send specifications to the address below for obligation-free recommendations.

DELAVAN Manufacturing Company

WORLD'S LARGEST MANUFACTURER OF NOZZLES • WEST DES MOINES • IOWA

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COMPUTER for missile firing

This special computer can determine ballistic wind effects rapidly and accurately direct from pilot balloon data. It incorporates two adjustable non-linear function generators making possible adjustments in non-linear inputs to the computer with a minimum of time and calculation, says **Perkin-Elmer Corp., Dept. S/A, Norwalk, Conn.**

The computer displays the data in the form of an X and Y coordinate change (north-south and east-west). It provides for an automatic data input from a theodolite, that enables continuous computations. Other input data are an assumed rate of rise of the test balloon, and the rho factor. The computer automatically reads out how many miles north-south and east-west the point of impact of the missile will be offset by the ballistic wind. The result enables final adjustments to be made in the tilt of the launching mechanism.

Write in No. 302 on Reader Service Card

LATCHING RELAYS are microminiature

This series of balanced armature dual coil microminiature latching relays, Model R650, are postage stamp size and met and exceeded MIL-R-5757C with vibration immunities of ten to 55 cps at a total excursion of 0.200 in. and 55 to 2000 cps at 30 g's and shock immunities of 100 g's, says **Iron Fireman Electronics Division, Dept. S/A, 2838 S.E. Ninth Avenue, Portland 2, Ore.**

The units have a contact rating of two amperes resistive at 28 V dc or 115 V ac, and a minimum life of 1000,000 operations at 125 deg C. The relay is activated by a five millisecond pulse of 300 milliwatts.

Write in No. 303 on Reader Service Card

MOTOR OR PUMP for high temperatures

Designed primarily for use as a hydraulic motor to drive a fuel booster pump, this hydraulic motor, Model P-975, can be used as a pump in a closed hydraulic circuit. The overall efficiency remains the same whether the unit is operated as a pump or motor, says **Lear-Romec Div., Lear, Inc., Dept. S/A, Elyria, Ohio.**

With a 7.3 gpm flow the hydraulic motor develops 11 hp at 4400 rpm with a 3000 psi differential and is operable in fluid temperatures from —65 to +450 deg F. It is fabricated from temperature stainless and tool steel throughout.

Write in No. 304 on Reader Service Card

BOSS CONNECTOR has all-metal seal

This "Invermeto" inverted nut and sleeve boss connector for aircraft and missile boss seals permits connection of tubing directly to the boss. Fitting eliminates one connector and one sealing point. The boss configuration results in a 68% fitting weight reduction of a —10 steel system, according to **Weatherhead Co., Dept. S/A, 300 E. 131 St., Cleveland 8, Ohio.**

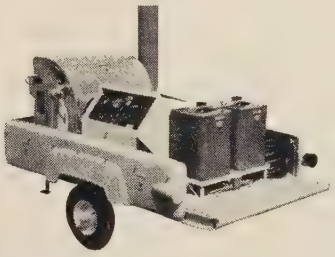
Other advantages include: elimination of elastomeric seal ("O"ring) permits use of the boss at elevated temperatures and in fluid environments which would adversely affect the elastomer; fittings can be easily rotated and locked in any required position; utilization of the MS flareless fitting concept, which has been upgraded for advanced fluid systems, including cryogenics and non-flarable high tensile tubing.

Write in No. 305 on Reader Service Card

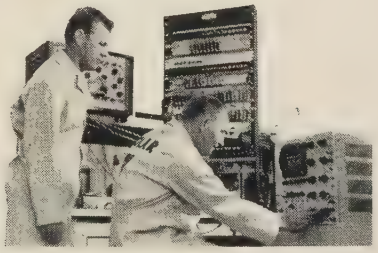
more on page 242

SUPPORT!

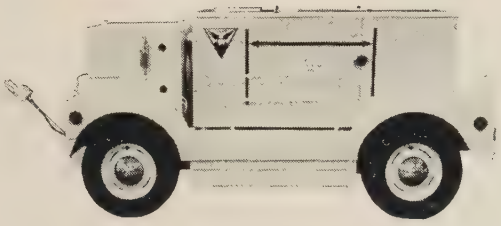
Solar skills and capabilities cover full range of support equipment



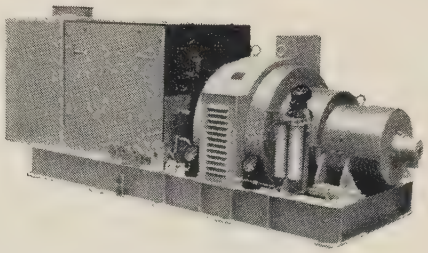
WHEELED VEHICLES: Solar's GSE capabilities include the design, development and manufacture of specialized powered and towed vehicles—including large trucks and semi-trailers—for missile transport, ground handling and other important support applications.



ELECTRONIC EQUIPMENT: Electronic Systems Development Corp., a Solar subsidiary, has broad experience in electronic systems for airborne, shipboard and ground installations—including missile checkout, data processing, communications, ground test and others.



MULTI-PURPOSE SERVICING UNITS: Support equipment is a natural outgrowth of Solar's early experience in fabricating advanced metal structures for specialized applications. Current units include dolly- and truck-mounted starting and servicing units for advanced military and commercial jets.



POWER PACKAGES: Solar emphasizes reliability in all of its support equipment. Among the more than 2000 major units of support equipment produced by Solar are reliable, lightweight gas turbine-driven generators for important ground, airborne and shipboard applications.

Underlying Solar's support equipment capabilities is a weapon systems team of selected scientists and engineers with years of active experience in the GSE field. For detailed information write today to Dept. G-139, Solar Aircraft Company, San Diego 12, California.

SOLAR
AIRCRAFT COMPANY
SAN DIEGO
DES MOINES

ENGINEERS WANTED! Challenging projects, unlimited opportunities with Solar.

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NEW ENDEVCO
VIBRATION
SYSTEMS
Featuring Transistorized charge amplifier and hermetically sealed accelerometer. You can use up to 300 feet of cable between amplifier and accelerometer —with no signal loss.
Complete Endevco system qualifies to MIL E 5272. Temperature range —40°F to +230°F. Frequency response from below 10 cps to above 10 KC. Entire system isolated from ground.
Endevco System Amplifiers and Transducers are described in the "2200" and "2600" literature. Write for your copies today.
dynamic instrumentation
ENDEVCO CORPORATION
Department M
161 East California Boulevard
Pasadena, California
Write in No. 174 on Reader Service Card at start of Product Preview Section

PRESSURE SWITCH for aircraft

This new pressure switch for the aircraft and missile industry, is designed for use with fuel, water-alcohol mixtures, hydraulic, pneumatic, engine oil systems. It has a pressure sensing range from five to 400 psig and a proof pressure to 500 psig. Its tempemperature range is from —65 to +275 deg F. Its electrical rating is ten amps resistive at 14-30 Vdc. The switching element is snap-action type spdt or spst (N. O. or N. C.). Its electrical connector is type AND 10066C hermetically sealed, or free leads can be furnished. The pressure port is AND 10050-4 or MS 33656, says **Frebank Co., Dept. S/A, 711 W. Broadway, Glendale 4, Calif.**

The stability and durability of the switch is such that its components will not alter in their characteristics during operation. It has a maximum weight of five ounces. The unit is pre-set, safety-wired and sealed at the factory.

Write in No. 306 on Reader Service Card

TERMINAL BLOCK is gold-plated

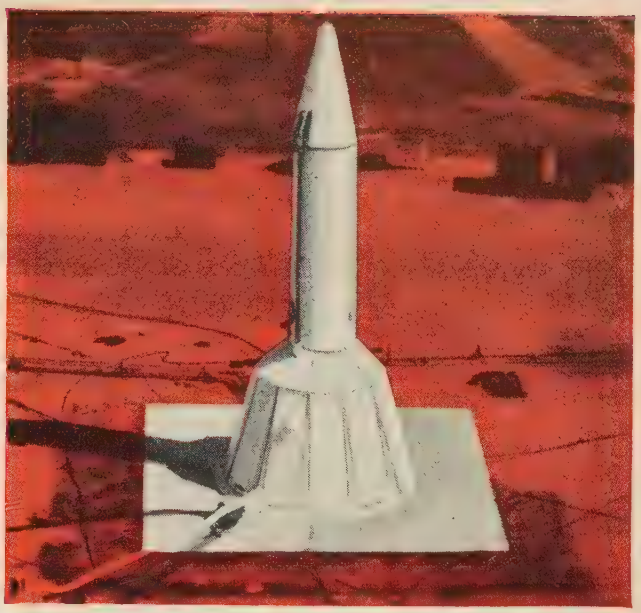
This terminal Block, T-1000, for use with ground support equipment is constructed of a molded phenolic base with reinforced barriers between terminal cavities; one cavity will accommodate four terminals. Up to 40 connections can be madewith one block; adjacent terminals can be bussed together with special connectors, says **Twin Lock Inc., Dept. S/A, 1024 W. Hillcrest Blvd., Inglewood, Calif.** The block measures five inches long, by $1\frac{1}{16}$ in. wide, by $\frac{3}{4}$ in. high.

The terminal lugs (available in bulk or in strip bands of one to 3000 for automatic assembly equipment) and the block sockets are gold plated. Harness fabrication and assembly installation time can be cut by 50 per cent, it is claimed. The T-1000 has been accepted for ground support equipment for USAF prime contractors, approved for Federal Stores, Navy and Bureau of Ordnance Numbers and is approved under USAF MIL-E-005272B, MIL-STD-202A.

Write in No. 307 on Reader Service Card

more on page 244

HURRICANE-PROOF "OVERCOAT" FOR THE JUPITER...



MISSILE SHELTER-PANELS RAISED

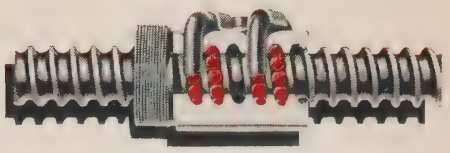
MISSILE SHELTER-PANELS OPEN

"buttoned up" by 24 Saginaw b/b Screws

Buttoning up the "overcoat" for the Jupiter IRBM is a cinch for the Saginaw Ball Bearing Screw! The "overcoat" is a portable prefab standby shelter designed by Barnes & Reinecke, Chicago, and U. S. Army Engineer Research and Development Laboratories, Fort Belvoir, Va., to protect the missile's tail and personnel working on it. The shelter has 12 base sections with hinged panels raised electrically to form a weather-tight seal around the Jupiter's hull.

The Saginaw b/b Screw converts *rotary* motion into *linear* with over 90% *efficiency*. This enables the Saginaw Screws to dependably raise or lower these panels—and hold the shelter securely in place—even in the face of 76 mph hurricane winds. In fact, each Saginaw Screw is able to withstand a combined wind and weight stress of almost five tons! The Saginaw Screw also offers substantial savings in space, power and weight which make the shelter easier to transport and assemble.

The Saginaw Screw may be able to give *your* products that valuable Sales Appeal you're looking for. To find out, write or telephone Saginaw Steering Gear Division, General Motors Corporation, Saginaw, Michigan—*world's largest producers of b/b screws and splines.*



Give your products NEW SALES APPEAL... switch to the Saginaw ball bearing Screw

WORLD'S MOST EFFICIENT ACTUATION DEVICE

NEW QUALITY SEAL® HYDRAULIC and PNEUMATIC CHECK VALVES

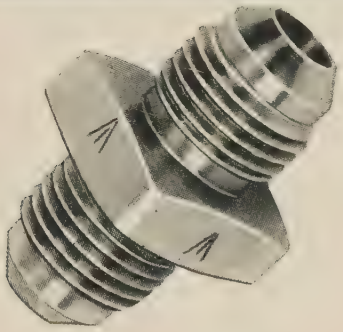
SMALL
Save space . . . compact design. Light in weight.

LEAK-PROOF
New design seal with dual seating action guarantees a leak-proof valve at both high and low pressures.

ULTIMATE PERFORMANCE
Full flow with extremely low pressure drop. Chatterless, vibration-free action. Quick opening and positive closing.

RELIABLE
Engineered and tested for maximum safety and performance. Precision manufactured to meet the most stringent military and industrial requirements.

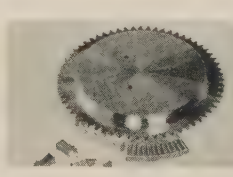
VERSATILE
Standard sizes available for tube connection ¼" to 2". May be incorporated in other fittings such as reducers, elbows, etc.

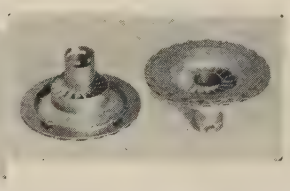


Wrench portion made square to differ from standard AN & MS fittings.

QUALITY CONTROL CORP., Write for details.
7315 W. Wilson Avenue, Chicago 31, Illinois
Designers & Manufacturers of Precision Hydraulic & Pneumatic Products

Write in No. 175 on Reader Service Card at start of Product Review Section

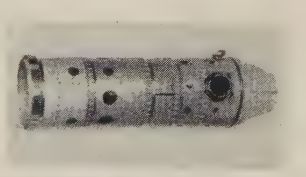


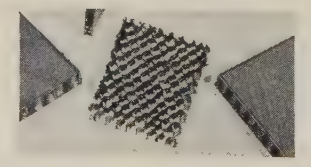


We Furnace Braze Stainless Alloys

To eliminate problems of distortion, stress, oxidation, and porous welds

The advantages of stainless alloy brazing in dry hydrogen or vacuum environment furnaces are many. And the use of brazing for high-temperature service parts is growing just as fast as potential users learn to design for it. We offer technical design assistance to further the acceptance of this modern joining technique. Ten years of pioneering this field, plus operating three stainless processing plants, plus manufacturing our own Nicrobraz® brazing alloys, fully qualifies us to give initial guidance to your design crew in planning brazed stainless components. Call TWinbrook 3-3800 in Detroit, or write to find out how we might help you.





STAINLESS PROCESSING DIVISION
WALL COLMONOY CORPORATION
19345 John R Street • Detroit 3, Michigan
There are Wall Colmonoy furnace plants in Detroit, Michigan; Morrisville, Pennsylvania; and Montebello, California

Write in No. 176 on Reader Service Card at start of Product Preview Section

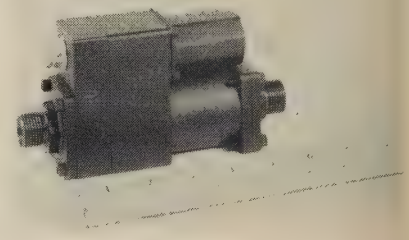
PANEL SWITCH LIGHT has 28-v circuit

This dpdt double break Switch-Light Combination with independent 28 V lamp circuit for panel mounting is supplied in momentary snap action or push-on push-off snap action. Contacts are rated at 28 V dc five amperes inductive, operating pressure is about four pounds with 5/32 in. overall travel, ⅝ in. mounting thread, says **Pendar, Inc., Dept. S/A, P.O. Box 3355, Dept. T., Van Nuys, Calif.**

Switch case is ⅞ in. in diameter. Length from mounting surface to and including terminals is 1⅜ in.

Write in No. 309 on Reader Service Card

MASS FLOWMETER is miniature



This miniaturized aircraft mass flowmeter, type TJ-61, provides a continuous indication of the mass rate of fuel flow up to 5000 lb per hour. It is designed for use on small jet and turbo-prop engines, says **General Electric, Dept. S/A, Schenectady 5, N.Y.**

A self-contained frequency compensator in the compact self-synchronous system permits operation from 400 cycle, 115V ship's power which does not have close frequency control. No external power converter is needed.

Write in No. 310 on Reader Service Card

LUBRICANTS for lox systems

This line of impact-insensitive inorganic lubricants and thread sealants, Oxylube 701, 702, 703, for use in lox systems or in areas subject to lox spillage, is completely unaffected by impact testing to 185 ft lb in the presence of liquid oxygen, says **Drilube Co., Dept. S/A, 723 W. Broadway, Glendal 4, Calif.**

In addition, the three lubricants do not spall, flake, become brittle or lose their adhesion when immersed in lox under standard test conditions, it is said, Oxylube 703, designed as thread sealant and lubricant, provides a positive leakproof seal at pressures up to 10,000 psi.

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more on page 246

Reeves INSTRUMENT CORPORATION

. . . first in today's front page developments

TO THE MOON...OR BEYOND...

Verlort can track it. As an example of Reeves Systems Engineering and production capabilities, Very Long Range Tracking Radar (VERLORT) was successfully designed and produced within a period of six months to meet urgent requirements of the DISCOVERER ground-tracking program.

This remarkable beacon radar system can achieve extreme tracking ranges . . . to the moon and beyond. Ingenious circuit design eliminates the possibility of either range ambiguity or interference between transmitted and received signals.

Equally advanced research and development, teamed with complete, full-scale production facilities, are available for the solution of your own pressing problems in the fields of missile and vehicle guidance, tracking and fire control systems, computer systems, and components.

a highlight on CREATIVE SYSTEMS ENGINEERING at Reeves

Qualified engineers seeking rewarding opportunities in this and other advanced fields are invited to get in touch with us.

Reeves INSTRUMENT CORPORATION

REEVES INSTRUMENT CORPORATION

A Subsidiary of Dynamics Corporation of America—Roosevelt Field, Garden City, New York

7RV59

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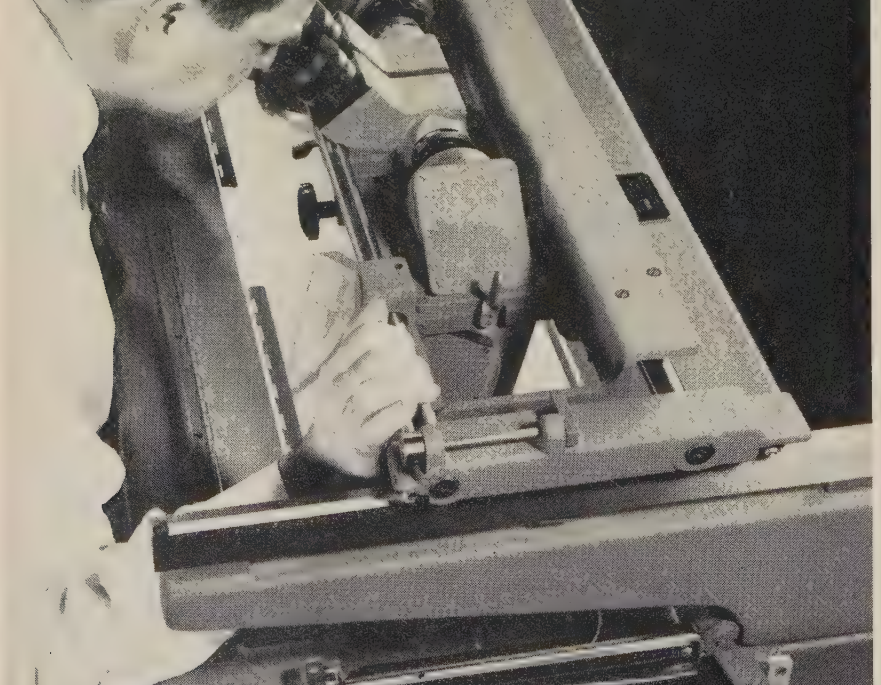
Here's new help in photo interpretation

Now you can view uncut aerial negatives in roll form. This Scanning Stereoscope that speeds first phase studies is typical of the help available from Bausch & Lomb. Here at B&L you'll find capability for high, low and medium magnification systems . . . for formats from 70mm to 18″ x 18″ . . . for low and high tilt rectification. What's your problem? We'd like to help. Just drop a line to Bausch & Lomb Optical Co., Photogrammetric Dept., 15745 St. Paul St., Rochester 2, N. Y.



Write in No. 178 on Reader Service Card at start of Product Preview Section

TV CAMERA withstands rocket roar

This TV camera, Model 1986CN, designed specifically to resist sound levels that would shatter the hearing of a human observer, can operate in noise environments up to + 145 db without an acoustical housing. With a housing, it is virtually impervious to noise of any level. It has been successfully used in sound levels above 190 db, says **Kintel, Dept. S/A, 5725 Kearny Villa Rd., Box 623, San Diego 12, Calif.**

Immediate application claimed for the new camera is on rocket or jet engine test stands, since it is essentially free of microphonics. It features a video-signal amplifier with subminiature tubes mounted in a unique heat sink. The result is a dampening out of sound vibrations, plus full thermal protection. The camera provides 600-line resolution. Picture circuits have a bandwidth of 20 cps to eight mo ±½ db. It weighs seven pounds.

Write in No. 312 on Reader Service Card

SWITCH for cam-applied force

The Unimax type 1SR1-1 is a subminiature, snap-acting switch for use where operating force is applied by a cam The stainless steel roller provides long wearing low friction bearing on the actuating cam and the spring plunger permits 0.031 in. over travel. The plunger mechanism is integral with the mounting bracket, in which a basic Unimax USM5 subminiature switch is secured. The ¼ in. —40 threaded bushing permits single-hole mounting in a panel up to ¼ in. thinck. A keying tab is provided. The basic switch in this unit meets MIL-S-6743 and MIL Drawing MS-25085-1, says **W. L. Maxson Corp., Dept. S/A, Ives Rd., Wallingford, Conn.**

Rated at 2.5 amps, 30V dc, inductive; five amperes, 30V dc, resistive; five amperes, 125/250 V ac, the Type ISRI-1 has single-pole, double-throw action.

Write in No. 313 on Reader Service Card

more on page 248

The Hand with the

Golden Touch

uses A.W.Faber-*CASTELL*

with **BLACK GOLD**

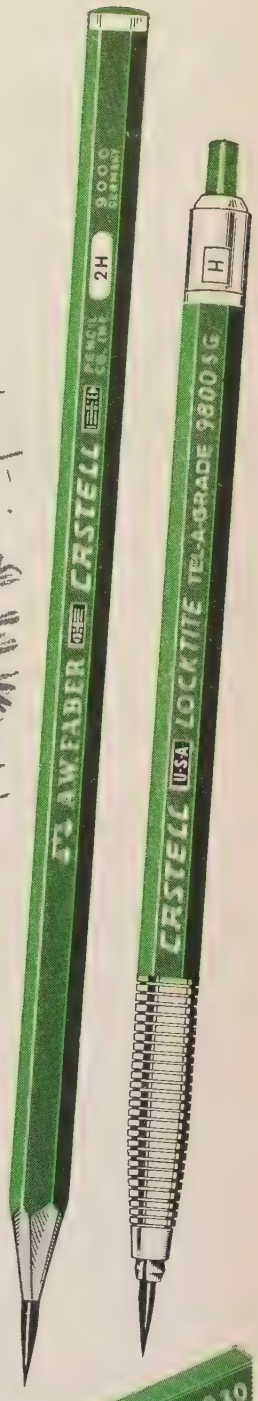
CASTELL drawing pencils in the hands of the men with the "golden touch" transform the incredible of yesterday into the normal today. You'll find these men in practically every creative office, working as engineers, architects, designers and draftsmen.

Why this overwhelming preference for CASTELL? Because CASTELL is made from the world's finest *natural* graphite that tests out at more than 99% pure carbon. Because it contains no smudgy, smeary foreign substance to give the false illusion of black.

CASTELL is truly worthy of your designing talent, your rendering, your perspective or your tracing. It is your dependable graphite drawing tool that transforms your grey matter into black matter on paper or cloth.

CASTELL will not make you a genius overnight, but it will give the "golden touch" to your eager, sensitive fingers and your creative mind. It costs no more to use the world's finest drawing tools—CASTELL wood pencils in 20 superb degrees, 8B to 10H, imported CASTELL leads and Locktite holders with the bulldog grip. Order today.

Choose from: #**9000** CASTELL Pencil. #**9007** CASTELL with Eraser. #**9800SG** LOCKTITE TEL-A-GRADE Holder with new functional spiral grip and degree indicating device. #**9030** CASTELL Refill Lead matching #9000 pencil in quality and grading, packed in reusable plastic tube with gold cap. Other styles and colors of pencils, holders and refill leads.



Castell Leads and Pencils draw on all surfaces, including Mylar-based polyester drafting films. Give perfect lines, easy to erase —excellent reproduction.

BACKED BY NEARLY 200 YEARS UNINTERRUPTED MANUFACTURING EXPERIENCE — SINCE 1761

FABER-CASTELL

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A.W.FABER-CASTELL Pencil Co., Inc.
Newark 3, N. J.

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Corles Perkins, Chief of Flight Control Systems
Honeywell Aeronautical Division

"I need analytical, systems, component engineers to work in flight control systems"

"Our team at Honeywell introduced the first successful electronic autopilot in 1941—the C-1 of World War II fame. Since, we have produced more flight control systems than any other company and have developed concepts in flight control that are now standard in this field. Today, most top aircraft and missiles are equipped with Honeywell flight controls. Our group has expanded steadily and now we need additional engineers.

"I'm looking for *analytical* engineers capable of simulating (mathematically on paper or computers) characteristics and problems in missiles and aircraft control, stability, and control systems. These men have good math backgrounds with analog computer experience.

"*Systems* engineers for our group should be capable of interpreting analytical results into navigation, guidance, or flight control systems. They should be electrical engineers experienced in systems—ideally, with experience in flight control in the aviation industry.

"*Components* engineers should be electronics men with emphasis on transistor circuitry. These are the men responsible for designing components which go into the system. Must have circuitry design experience.

"If you fit one of these categories, I'd like to hear from you. Just drop a line including pertinent information on your background, interests, and accomplishments to my Technical Director, Mr. Bruce D. Wood. He will arrange a meeting—to answer your questions about Minneapolis-Honeywell—to discuss your plans and the possibility of a career with Honeywell."

Write: Bruce D. Wood, Technical Director, Dept. 847-B

MINNEAPOLIS **Honeywell** H HONEYWELL

AERONAUTICAL DIVISION

1433 Stinson Blvd., N.E., Minneapolis 13, Minn.

Fine opportunities also exist in other Honeywell development and manufacturing facilities in the Boston area, Philadelphia area, Los Angeles area, Minneapolis, Seattle, St. Petersburg, Chicago and Freeport, Illinois, Denver and the Washington, D.C. area. Send resumé to H. D. Eckstrom, Dept. 847B, Director of Employment, Minneapolis Honeywell, Minneapolis 8, Minnesota.

Check Employment Inquiry Form on Page 183

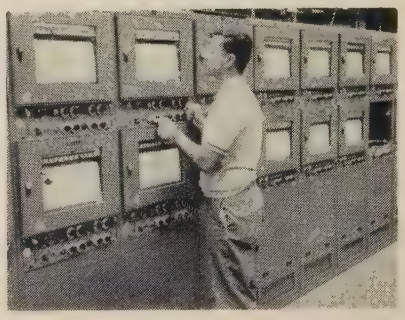
CONNECTORS
have 2 taper pin rows

This new series of printed card connectors, type UPCC-FDTP, have two rows of taper pin terminals linked mechanically and electronically for use with AMP 53 taper pins. Positive reentrance of the male pins is assured each time by the Molding Assist Closed Entry, says **U.S. Components, Inc., Dept. S/A, 454 E. 148th St., New York 55, N.Y.**

The connectors are available in total contacts of seven, 11, 15, 19, 23 and 32 or custom configurations may be obtained. The new dual row taper pin series is ideal for critical environmental conditions and extremes or military applications.

Write in No. 314 on Reader Service Card

INSTRUMENT CABINETS
for missile firings



These Emcor Cabinets are part of a test facility designed for observing performance of the engine and other components without expending a missile. During these firings, the missile is held firmly in a superstructure.

The use of Emcor Modular Enclosures in the test facility presents a compact, centralized and interconnected control center. Human engineering features of the modular cabinet design bring all equipment within easy reach and sight of the operator, says **Elgin Metalformers Corp., Dept. S/A, 630 Congdon Ave., Elgin, Ill.**

Write in No. 315 on Reader Service Card

COMPOUND
resists fuming nitric

Attack and degradation of rocket and missile components by red fuming nitric acid can be successfully resisted by Compound 18007, according to **Precision Rubber Products Corp., Dept. S/A, 3110 Oakridge Dr., Dayton 7, Ohio.** Severe testing is reported to have disclosed no evidence of flex cracking, and resistance to compression set is excellent.

The flexible material showed a 6.4 per cent deflection after aging of 70 hrs at 250 deg F, about 25 per cent (minimum) less than that for high grade industrial specification materials similarly aged.

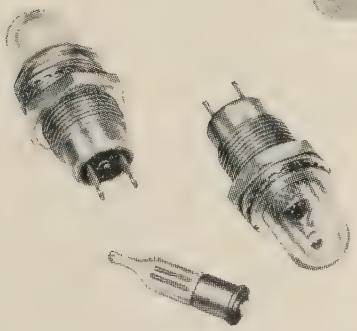
Write in No. 316 on Reader Service Card

more on page 252

HETHERINGTON

SWITCHES • INDICATOR LIGHTS • SPECIAL ASSEMBLIES

ENGINEERING NEWS



"RESISTORIZED" NEON INDICATOR

...to MIL-L-6723 (ASG)

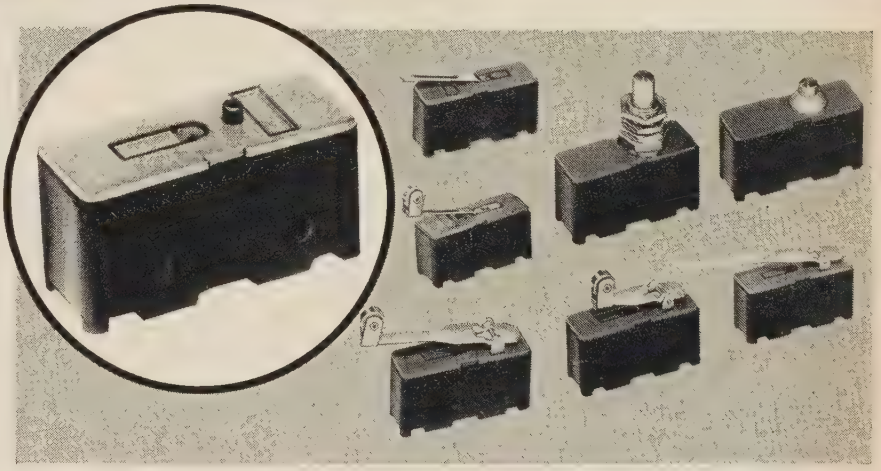
Keeping pace with the needs of miniaturized, ruggedized, transistorized equipment of minimized dimensions, Hetherington engineers have found space for an internal resistor in an indicator light that already is only $1\frac{33}{64}$" long. It's known as the Hetherington L15,000 Series and it's designed to MIL-L-6723 (ASG), Drawing MS25257. With the built-in resistor, the unit operates on 115 volts using MS25252-NE2D neon lamps.

If low-voltage incandescent lamps are preferred, $\frac{11}{32}$" in length can be saved by specifying the still smaller L14,000 Series, designed to MS25256.

Both types have corrosion-resistant anodized aluminum sockets with integral mounting flanges, panel indexing tabs, and two solder-lug terminals. Lamps replace from the front by unscrewing the wide-visibility lenses. Center contacts are large silver-plated buttons, internally spring-loaded to resist vibration.

Complete specifications on both MIL-L-6723 (ASG) lights are shown in Data Sheet L-5a.

Write in No 100 on Reader Service Card



New 20-AMP PRECISION SWITCHES

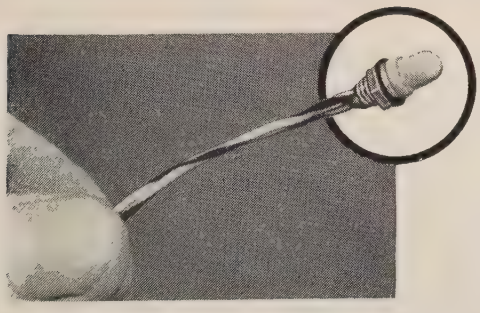
braced for toughest service!

Rigidly-braced phenolic cases of Hetherington Series S2A "HiPAC" Switches pave the way toward greater dependability and unsurpassed repeatability in critical control and positioning circuits. Molded-in safety limits prevent over-travel damage to the blade-type movable contacts. Extra bracing around mounting holes prevents case distortion from excessive mounting pressures. On the bottom, molded-in barriers and cup washers provide long creepage paths and positive separation between terminals and leads.

U. L. rated "HiPAC" Switches are presently available with any of eight actuators. All are interchangeable with other precision switches of equivalent ratings. Quantities for samples or small production runs are stocked for immediate delivery by over 50 leading electronic parts distributors throughout the country.

For detailed specifications on the "HiPAC" line, write for Hetherington Bulletin S-9.

Write in No. 101 on Reader Service Card



TINY LIGHT with a BRIGHT FUTURE

One of the smallest indicator lights ever developed, the Hetherington L10,000 Series measures only $\frac{15}{64}$" in diameter by $\frac{35}{64}$" long. It's equipped with wire leads and a threaded aluminum bushing that mounts in a clearance hole for a #10 screw. Secret of the L10,000's midget size is a fully moistureproof lamp/lens assembly that is molded to the mounting stem.

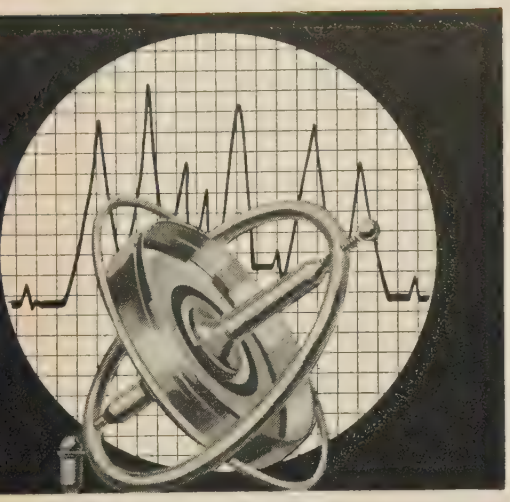
Designed for electronic equipment requiring components of minimum size and weight, the L10,000 gives bright, wide visibility for 60,000 hours at 5 volts dc. Many translucent colors are available.

Dimensions of the L10,000 are available on request.

Write in No. 102 on Reader Service Card

HETHERINGTON INC. DELMAR DRIVE, FOLCROFT, PA. • 139 Illinois St., El Segundo, Calif.

A Controls Company of America Subsidiary



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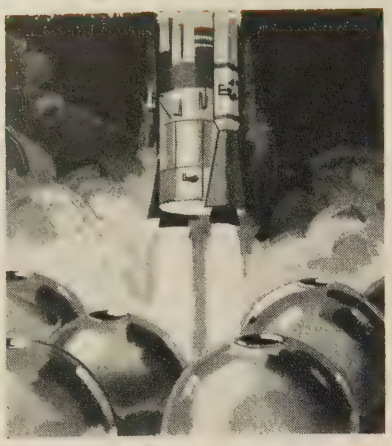


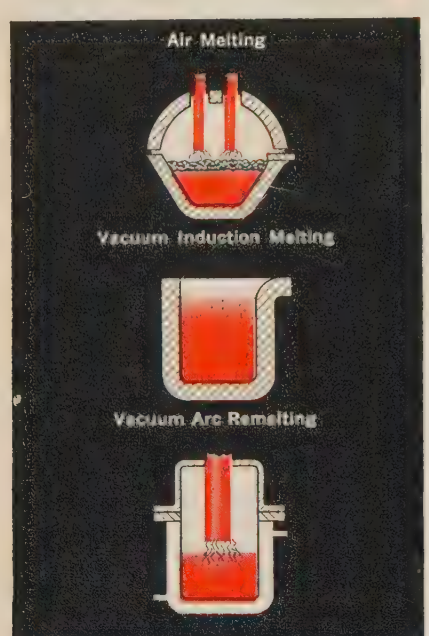
c

a. Titanium slabs are heated prior to rolling into continuous sheet coils. Crucible's increased capacity for producing high purity metals, in all sizes and mill forms, is substantially reducing costs and delivery times.

b. ***Vacuum Melted Alloys*** *are specified for gyroscope balls used in navigational and fire direction systems. The metals' improved properties facilitate miniaturization.*

c. ***Titanium*** *helium storage bottles for ICBM Atlas. Titanium, which must be vacuum melted, was selected because of its high strength weight ratio, cold-resistant properties and corrosion resistance.*

d. ***Basic Melting Processes.*** *Vacuum induction melting produces "purer" metals than conventional air melting because it eliminates all sources of contamination except the crucible. Vacuum arc remelting eliminates the crucible and permits production of ingots up to 18,000 lbs.*



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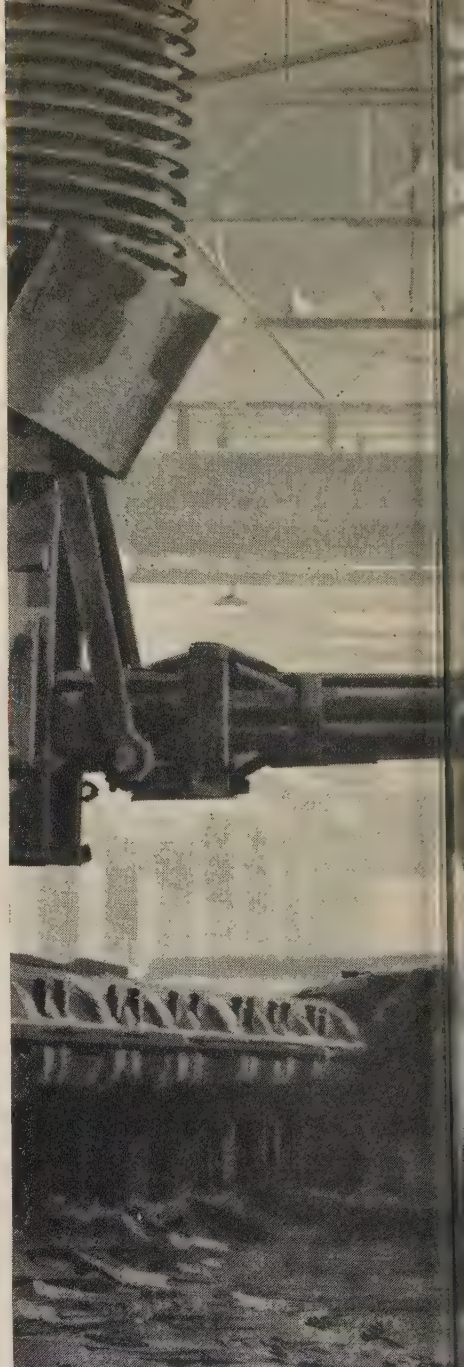


VACUUM MELTING CREATES

Marked improvements in properties produced by High-Purity Metallurgy

Behind the development of space-age metals with entirely new characteristics is vacuum melting — a series of processes that produce "purer" metals with better properties.

Why Vacuum Melt? Vacuum melting protects molten metal from contact with air. It also provides closer control of composition, helps eliminate inclusions, and minimizes center porosity and segregation in ingots.

In the field of vacuum melting, Crucible's position is unique. As the leading producer of special purpose steels, Crucible's experience in high-quality steelmaking is unsurpassed. Through formerly affiliated companies, now fully integrated with it, Crucible led in the development and commercial production of vacuum-melted steels, iron, nickel, copper — and titanium. Therefore, Crucible's breadth of experience, together with its extensive facilities, places the company in the best position to provide the "super-quality" metals most suitable for any given application.

The three vacuum-melting processes — One of the Crucible processes is VIM — *vacuum induction melting*. It starts with very high-purity raw materials, produces extremely pure ingots. A second is VAR — *vacuum arc remelting*, or the consumable electrode process. This process, starting with air-melted electrodes, produces large ingots — up to 32″ diameter x 18,000 lbs. It provides

SUPER-DUTY METALS

metal with low-gas content and greatly improved uniformity of properties. The third process is VIR — *vacuum arc remelting of vacuum induction melted electrodes*—a double-melting technique. It permits manufacture of super-pure metals in the full range of ingot sizes.

Crucible's experience with all three processes, and its facilities for vacuum arc remelting its own specially air- or vacuum-melted electrodes, provides industry with a complete range of vacuum-melted metals at the lowest possible cost. Only at Crucible is there available this experience, flexibility and the facilities for vacuum-melting titanium, superalloys, heat-resisting alloys, bearing steels, tool steels, stainless steels, electronic alloys and nuclear reactor materials.

If you'd like to know more about Crucible's work in High-Purity Metallurgy, read: "Quality Aspects and Properties of Vacuum Induction Melted and Vacuum Arc Remelted Steels and Super Alloys" and "Titanium for Aircraft and Spacecraft". Write: *Crucible Steel Company of America, Dept. AI-18, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

CRUCIBLE STEEL COMPANY OF AMERICA

Write in No. 180 on Reader Service Card at start of Product Preview Section

DYNAMICS ENGINEERS

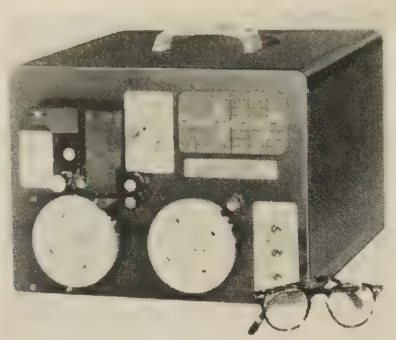
Immediate openings for vibration, flutter, and dynamic analysis engineers to work on the most advanced weapon systems—such as the B-70, the F-108, and the X-15, first manned space ship.

A background in AE, ME, or other applicable experience is necessary. Qualified vibration engineers will calculate and measure vibration levels for consulting on procedures to insure crew comfort and work out vibration environment problems on equipment of particular airframes. The flutter and dynamic analysis engineers will evaluate flutter characteristics, including servo systems, of particular airframes by analytical techniques and by the use of dynamic models, and conduct other studies relating to gust penetration, landing, and taxi conditions.

For more information please write to: Mr. F. J. Stevenson, Engineering Personnel, North American Aviation, Inc., Los Angeles 45, California.

THE LOS ANGELES DIVISION OF
NORTH AMERICAN AVIATION, INC.

DATA SCOPE records, projects

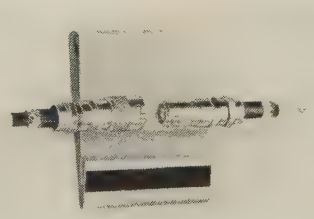


This "Datascope" is a recording-projecting oscillograph, enabling permanent immediate visual form for any physical variable—electrical, optical, acoustical, chemical or thermal. Transient phenomena ranging from DC to 5000 cps are permanently recorded and immediately projected as an enlarged image on a 4-inch viewing screen. The data may be transported backward and forward for detailed visual inspection. Recorded wave forms may be projected directly to a wall screen, or sections may be extracted as slides for future study, according to **Microsound, Inc., Dept. S/A, 4627 Leahy St., Culver City, Calif.**

Tests can be resolved in seconds.

Write in No. 317 on Reader Service Card

CABLE CONNECTORS are very small



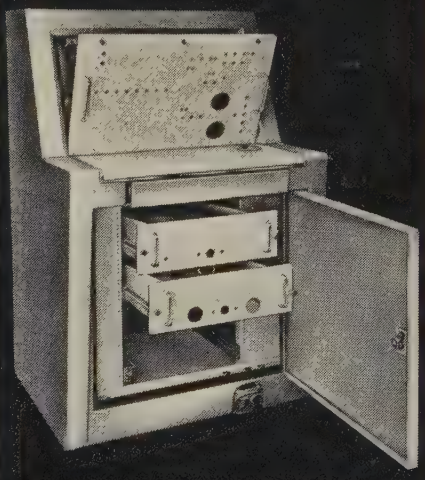
This series of miniature, tri-axial connectors are said to be the smallest tri-axial type available. Plugs and jacks measure one inch by ⅜ in., yet they provide two separate concentric shields, accommodate cables up to 212 o.d. and have a 500 V rated capacity, says **Dage Electric Co., Inc., Dept. S/A, 67 N. Second St., Beech Grove, Ind.**

These connectors are bayonet locking, have teflon insulation and are available in four different polarity groups. The connectors, it is said, are field serviceable, require no special tools for assembly and withstand a cable pull of over 50 lb. Dage miniature, they may also be used with coaxial cable from 0.060 to 0.250 in. o.d. where ungrounded systems are required.

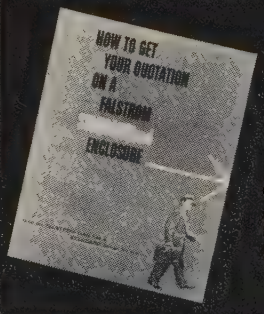
Write in No. 318 on Reader Service Card

more on page 254

WHAT IS A STANDARDIZED CONSOLE



A Console especially designed so as to be easily adaptable to your individual requirements at economical cost. Provides for easy accessibility, time-saving and efficient operation. In aluminum and other metals and alloys.



Write, wire or telephone for complete information.

FALSTROM COMPANY
172 Falstrom Court, Passaic, New Jersey
PRescott 7-0013

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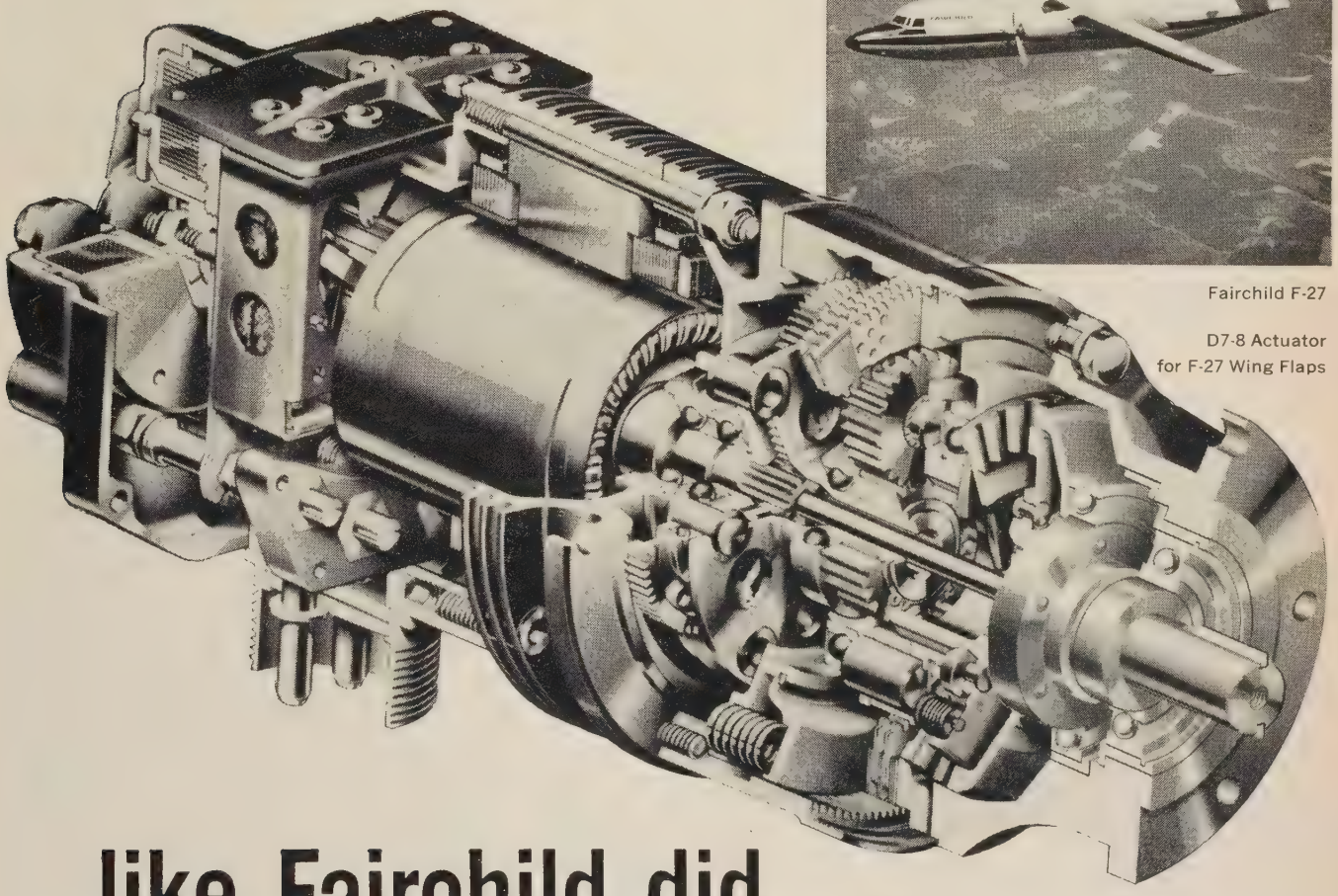
Check Employment Inquiry Form on Page 183

ACTUATE...

Fairchild F-27



D7-8 Actuator
for F-27 Wing Flaps

...like Fairchild did with its F-27

Come to Jack & Heintz with your actuator problems. We will work with you, as we did with Fairchild, to research, design and produce actuators or actuator systems for aircraft, missiles and ground support. J & H offers extensive experience in systems for military aircraft . . . plus the advantages of one location for complete development and production of the design. Talk to us about electric, hydraulic, electrohydraulic, electromechanical or pneumatic systems or components for linear or rotary actuation . . . in the applications listed. Or write: Jack & Heintz, Inc., 17634 Broadway, Cleveland 1, Ohio.

J&H ACTUATOR CAPABILITIES

AIRCRAFT
Wing Flap · Slat
Trim Tab · Canopy
Horizontal Stabilizer
Rudder · Speed Brake
Missile Carriage Drive
Bomb Bay Door
Wing and Fin Folding
Thrust Reverser

MISSILES
Engine Gimballing
Control Surface
Boom Folding

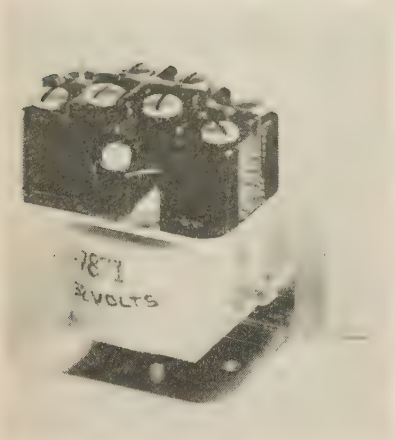
GROUND SUPPORT
Leveling · Erecting
Positioning · Spinning
Service Boom

JACK & HEINTZ, Inc.

SYSTEMS FOR AIRCRAFT, MISSILES AND GROUND SUPPORT

Write in No. 182 on Reader Service Card at start of Product Preview Section

HIGH POWER RELAY
is heavy duty



Featured in this new heavy duty power relay, is its ability to carry an extremely heavy load. The switch has been approved by Underwriters' Laboratories for a rating of 20 amperes, two horsepower at 230 V ac. Largest dimension of the relay is less than three inches; length is 2 1/16 in., and width about 1½ in., says **Robertshaw-Fulton Controls Co., Dept. S/A, Columbus 16, Ohio.** Modular design permits either switch or coil replacement without removing the relay from its mounting.

A variety of multiple circuit arrangements is available including: dpdt; spdt; dpst-nc; and dpst-no. Available coil voltages for ac include 24, 32, 115, and 230. For dc, 12, 30, and 115.

Write in No. 319 on Reader Service Card

INDICATOR
for excess pressure

This new device, Deltadyne, raises a red button to view when the differential pressure in a system exceeds a stated value. The unit is activated by differential pressures as small as five psi in systems with internal pressures as high as 5000 psi, says **Aircraft Porous Media, Inc., Dept. S/A, 30 Sea Cliff Ave., Glen Cove, N.Y.**

This device measuring one inch by 1¾ in. by two inches and weighing 0.27 lb for use in −65 to +275 deg F systems can be used to detect clogging of filters, spray nozzles and injection nozzles. It also will report excessive pressure drop in any part of a hydraulic or other fluid system, it is claimed. It can also be used in conjunction with an orifice or other flow restrictor to detect insufficient or excessive flow.

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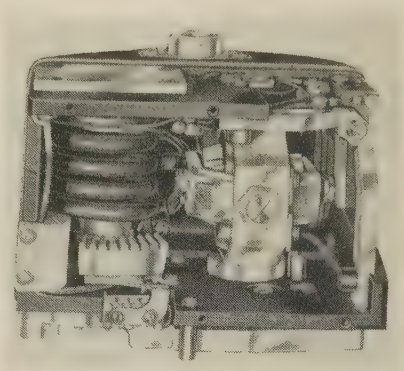
GYRO
has simple design



This spring driven two degree of freedom gyro for use in short range missiles and target drones, supplies a potentiometer signal to control roll with ±50 deg of freedom, says **Waltham Precision Instrument Co., Dept. S/A, Waltham, Mass.**

Its rotor is energized by a spring, bringing the rotor up to peak speed in a fraction of a second. Its simplicity of design makes it well suited to high-volume, low-cost applications, it is said. No warm up is required.

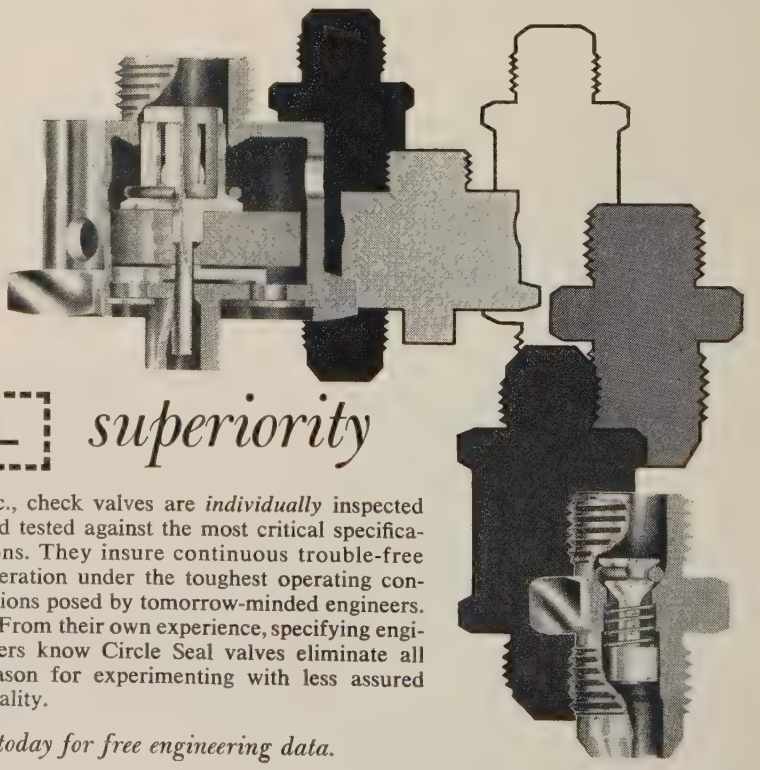
Write in No. 321 on Reader Service Card

more on page 256

1,000,000 A MILLION

Check Valves are proving

CIRCLE SEAL *superiority*



Today, with the experience gained in manufacturing over one million application-engineered Circle Seal check valves, James, Pond and Clark, Inc. is unique in its ability to meet the newest, most critical check valve requirements.

Rugged, high quality Circle Seal valves are a product of the valve industry's highest standards of quality. At James, Pond and Clark, Inc., check valves are *individually* inspected and tested against the most critical specifications. They insure continuous trouble-free operation under the toughest operating conditions posed by tomorrow-minded engineers.

From their own experience, specifying engineers know Circle Seal valves eliminate all reason for experimenting with less assured quality.

CIRCLE SEAL

precision valves

Please write today for free engineering data.

JAMES, POND & CLARK, Inc.

2181 EAST FOOTHILL BOULEVARD, PASADENA, CALIFORNIA

Write in No. 184 on Reader Service Card at start of Product Preview Section

FRENCH FLIERS CONQUER ANDES!

MERMOZ AND COLLENOT LINK ARGENTINA, CHILE!

Santiago, Chile, Feb. 2, 1928—The first successful commercial flight over the Andes mountains between Argentina and Chile was completed today when Jean Mermoz and Alexandre Collenot landed their Laté 25 monoplane at Copiapo, Chile, after a 900-mile flight from Buenos Aires, Argentina. The intrepid airmen overcame sub-zero temperatures and radiator difficulties to pave the way for a regular commercial air service between the two countries.

FIRST IN INTERNATIONAL AIR TRAVEL! Since the very beginning of international flight, the exploits of French aviators like Blériot, Bossoutrot, Noguès and Mermoz have made aviation history. Air France is proud to continue this tradition of French leadership in aviation by offering the most non-stop flights both ways between New York and Paris and the fastest jet service between Europe and the Middle East. And next year Air France will put into operation one of the largest pure jet fleets in the world.

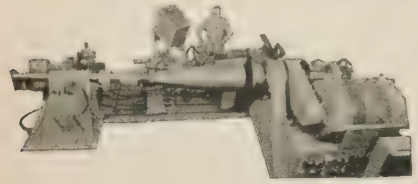
AIR FRANCE

WORLD'S LARGEST AIRLINE/WORLD'S FIRST INTERNATIONAL AIR SERVICE

Write in No. 185 on Reader Service Card at start of Product Preview Section

Announcing
COMPLETELY FLEXIBLE
PHOENIX
Powerspinning

To meet the challenge of the space age



Vanguard, Polaris, Talos, Jupiter and latest space projects utilize vital PHOENIX POWERSPUN components and assemblies.

Nose and tail cones, nozzles, venturi, bulkheads, guide vanes, exhaust hoods etc. are economically produced on Phoenix automatic, mechanical and manual metal spinning equipment in conjunction with complete welding, polishing, deep drawing and allied facilities.

High voltage spark-gap assembly produced by PHOENIX spin-fab method.

A Phoenix FIRST!
Flexible
POWERSPINNING
of metals, gauges and diameters heretofore thought impossible to form by spinning.

PHOENIX
Powerspinning
The modern way to
HYDRAULIC-SPIN
FLOW-SPIN
TURN-SPIN
SHEAR-SPIN
MECHANI-SPIN
AUTO-SPIN

Write for
40 Page Brochure

PHOENIX
PRODUCTS CO.
4741 North 27th St.
Milwaukee 9, Wis.

Write in No. 186 on Reader Service Card

TIMER
for program function

The Model 1000 Program Function Timer is specifically designed for missiles, aircraft and ground checkout applications. It can handle up to 16 separate circuit functions and is available with interchangeable switch, linear potentiometer, and nonlinear potentiometer function strips. It is designed to meet MIL-E-5272 says **Hub-Pot, Inc., Dept. S/A 13827 Saticoy St., Van Nuys, Calif.** The driving motor of the timer can be stopped or reversed at any point. The travel time for one cycle is 0.50 sec ±0.1 sec., short recycle times are available (⅓ of drivetime) The timing accuracy is ±0.5 per cent with a repeat accuracy of ±0.5 per cent.

Write in No. 322 on Reader Service Card

IMPACT SWITCH
is ultra fast

This single-action UFIS (Ultra Fast Impact Switch), capable of 90 microseconds from time of initial impact, appears promising for missile, drone, projectile, sled and kindred speed-measurement requirements, says **Servonics Engineering Services Co., Inc., Dept. S/A, 4645 Van Nuys Blvd., Sherman Oaks, Calif.**

The switch possesses a controllable time limit range from 90 to 200 microseconds, and is designed to meet current MIL specifications. Predetermined frangibility and variable specifications as to mounting base and other details, are offered. Temperature range is —80 to +185 deg F.

Write in No. 323 on Reader Service Card

RESOLVERS
in size 8

These winding-compensated resolvers now available in the miniature size 8 configuration are the first of their type to be manufactured on a commercial scale, says **American Electronics, Inc., Dept. S/A, 1025 West Seventh St., Los Angeles 17, Calif.** The resolvers are said to be smaller and lighter than their size 11 counterparts, with copper shading washers. liability of the heavier units. They weigh 1.2 oz, and have a frame diameter of 0.750 in. with maximum frame length of 1.241 in.

An important feature of the new size 8 resolver is that the slip ring and wiper assembly is designed to withstand high shock loads, up to 45 g at 2000 cps. Other features include corrosion resistant frames, and two phase rotor/stators with no sacrifice of critical characteristics.

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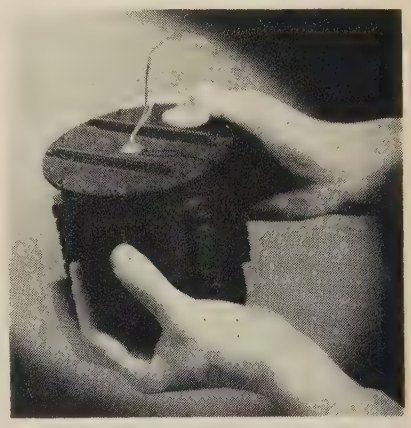
GENERATORS
are 6% efficient



This thermoelectric generator is a five watt unit about the size of a quart fruit jar, that operates at six per cent efficiency and is intended for use with an isotope heat source. It is designed to be cooled by air, says **Minnesota Mining and Mfg. Co., Dept. S/A, 900 Bush St., St. Paul 6, Minn.**

The new units are said to include some commercial applications. Cost of such generators will vary, depending upon various factors; particularly size. Units could conceivably range from ½-watt to several thousand watts, the company said.

Write in No. 325 on Reader Service Card

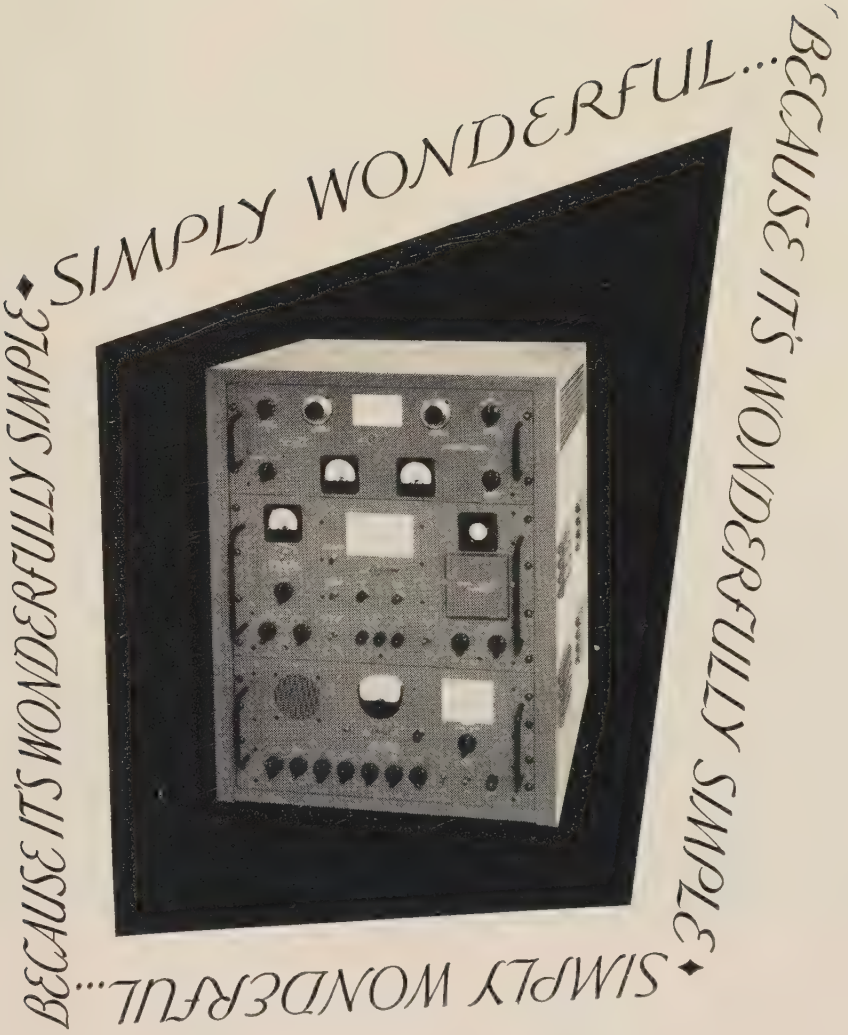
TITANIUM FILM
for metal coating

Thin films of tritiated titanium on stainless steel or molybdenum are coated about 0.7 microns in thickness on a two mil backing and contain one curie of tritium per square inch. It is completely stable in normal atmospheres, and is not appreciably affected by immersion in solvents or water or by exposure to acid fumes, says **Radiation Research Corp., Dept. S/A, 1114 First Ave., New York 21, N.Y.**

The material produces ion current in excess of 10_{-7} ampers per in. in air, and absolute beta emissions greater than 10_{-9} ampers per in. It is said to be suitable as a neutron source or as an ion producer in static eliminators, current regulating tubes, and vacuum gauges.

Write in No. 326 on Reader Service Card

more on page 258



Because of its wonderful simplicity, more and more governmental and business organizations are converting to Single Sideband communications systems by Eldico. In addition to the recognized advantages of SSB—far greater range, increased intelligibility, and a smaller package—Eldico equipment is engineered for pre-eminence in every way.

A case in point is the Eldico S-100 system, whose 100 watts minimum peak envelope power is equivalent to approximately 400 watts in AM gear. Use is greatly simplified by Eldico's preset channel selector, which requires no tuning by the operator. Only three "set and forget" controls are needed for operation, and optional remote features permit functioning up to five miles away. Thanks to Eldico's antenna tuner, only one antenna is necessary.

Faster communication is enabled by this true duplex system, with independent receiver and transmitter. It's supremely versatile, too, as the S-100 can be used in *all* modes of operation: SSB, AM, CW, and—with auxiliary gear—teletype.

The compact unit, which includes a microphone bias supply, is designed for easy servicing. Best of all, the Eldico S-100 is compatible with your existing equipment. Conversion to this advanced apparatus may be as gradual or prompt as you wish!

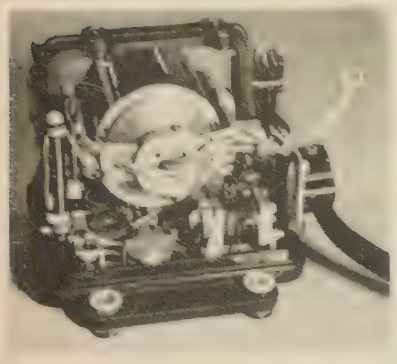
ELDICO

Radio Engineering Laboratories • Inc

Dept U • 29-01 Borden Ave • Long Island City 1, NY

Write in No. 187 on Reader Service Card at start of Product Preview Section

GYROSCOPE *has advanced damper*



This new rate gyroscope, the GG79, for indicating or controlling attitude rate of change for aircraft or missiles has an advanced damper and other design features permitting it to detect and control rates of yaw, pitch or roll in very rugged environments. A wide selection of turning rates, potentiometer resistances, and damping ratios is available, says **Minneapolis-Honeywell Regulator Co., Dept. S A, Minneapolis, Minn.**

The unit meets all requirements of MIL-E-5272 without change or adjustment. It weighs about 1.7 lb, and occupies a cube about 3.5 in. on each side. Its ambient temperature range is −65 to 165 deg F. Potentiometer resistance ranges from 420 to 15,000 ohms, and its threshold is 0.1 deg per sec or less. Power load is 45 W starting and 20 W running, operating with 115 V, 400 cps, single phase.

Write in No. 327 on Reader Service Card

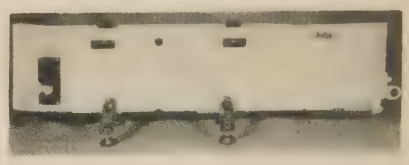
FREQUENCY STANDARDS *for missile environments*

Frequency standards designed to operate without frequency dividers in severe missile and aircraft flight environments have been announced by the **Gyrex Corp., Dept. S/A, 3003 Pennsylvania Ave., Santa Monica, Calif.** The new Gyrex Type JK instruments incorporate dynamically-balanced electro-mechanical resonators which operate without frequency or amplitude modulation even though fundamental frequency is in the missile vibration spectrum. This qualifies the instruments to meet various MIL specifications, including MIL-E-5272 A. Accuracy is within 0.01 per cent. All circuitry is transistorized.

Some of the general specifications include: Frequency: 200-10,000 cps; input: 24-30 Vdc; ambient temperature: −40 to 70 deg C, nominal; weight: about 12 oz max.; size 2½ in. dia by three inches long, nominal.

Write in No. 328 on Reader Service Card

RACK AND LAUNCHER *for bombs and rockets*



This sealed combination bomb rack and rocket launcher, Aero 25A, with explosive ejection features, weighs less than 26 lb, measures 37 in. long and 11 in. high. It is for any aircraft using outer wing stations. It can carry and launch any standard two lug, 14 in. suspended store up to 500 lb. The unit has been fully qualified by the Bureau of Aeronautics, U.S. Navy and meets all requirements including those for icing, vibration, shock, combined loading, overload, salt spray and frozen and dry sand, says **Lycoming, Div. of AVCO, Dept. S/A, 550 Main St., Stratford, Conn.**

The explosive ejection feature is said to literally blow the bomb or store away. High terminal velocity, ranging from five to 25 ft/sec can be obtained as required. The explosive force is generated by a standard Mark II Mod. O Navy Cartridge, fired electrically.

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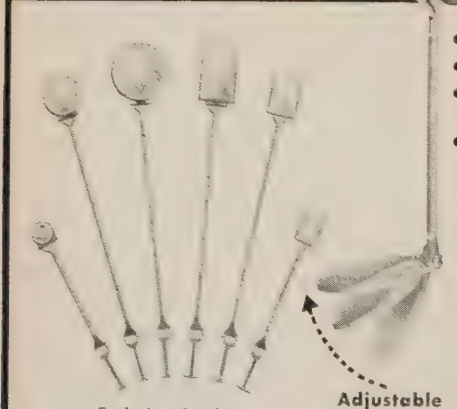
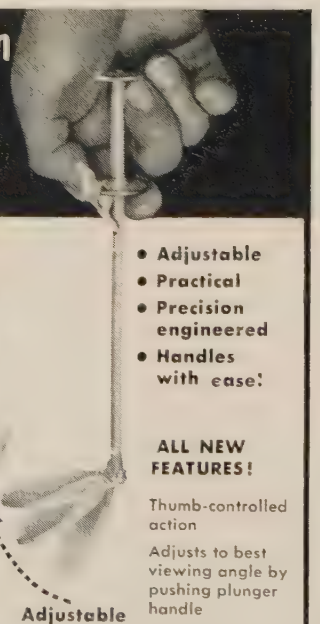
more on page 260

New! Thumb Action RATCHET Inspection Mirrors
Makes inspection easy!





- Adjustable
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- Precision engineered
- Handles with ease!

ALL NEW FEATURES!

Thumb-controlled action

Adjusts to best viewing angle by pushing plunger handle

Locks at any angle between 90° and 180°

Returns to straight position when thumb control is released

Easily inserted past obstructions

Adjustable

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- One-Hand Operation
- Precision Engineered
- Chromium-Plated Steel Handles and Mirror Cases
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RIDGEFIELD, CONN.

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BARCO

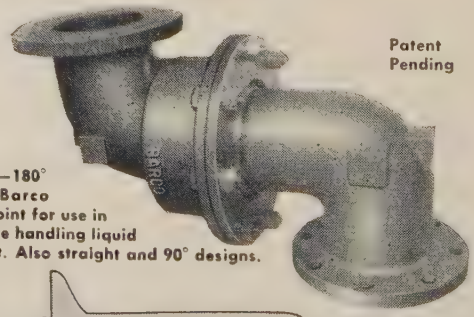
Flexible Joints for Handling Liquid Oxygen and other missile fuels

BARCO has the *specially designed* flexible joint which has passed the official "Qualification Test":

—Used in piping on fueling lines handling liquid oxygen, JP4 and JP5 fuel, white and red fuming nitric acid, and other chemicals.

—Provides swivel motion to allow for thermal expansion and contraction.

—High corrosion resistance. Other special designs available. For temperatures from −320°F. to +1,000°F., and higher. Also joints for gas and hydraulic service.



Patent Pending

(Right) 6"—180° flanged Barco Flexible Joint for use in fueling line handling liquid propellant. Also straight and 90° designs.

AIRCRAFT DIVISION

BARCO *Serving Industry Since 1908*
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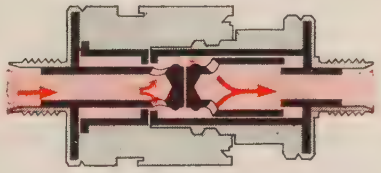
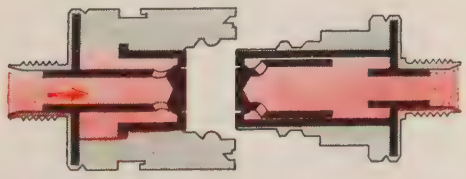
. . . it's a no-spill valved coupling by Snap-Tite!"

To use Snap-Tite Valved Coupling:



CONNECT—Full flow instantly



DISCONNECT—Stop flow instantly

The 15 Series valved coupling automatically snaps off the flow of the most volatile fluids when disconnected—with no leakage.

Snap-Tite's 15 Series valved coupling contains valves in both sections. Thus, the only fluid lost is that which clings to the outer metal surfaces. This coupling meets military specifications and can be used with fuels and other fluids to 3000 psi working pressure and 400°F. Sizes: ¼", ½", ¾", 1" in 6061T6 aluminum anodized; ⅜" in steel (electroless nickel plated), and 6061T6 aluminum.

Snap-Tite can provide the right valved coupling—with quick off-on action wherever coupling or shut-off is required—for most any use, most any fluid.

For more information, write for Snap-Tite Catalog #15. Snap-Tite representatives in all principal cities.

★ Snap-Tite

UNION CITY 14, PA.

ST-59-03

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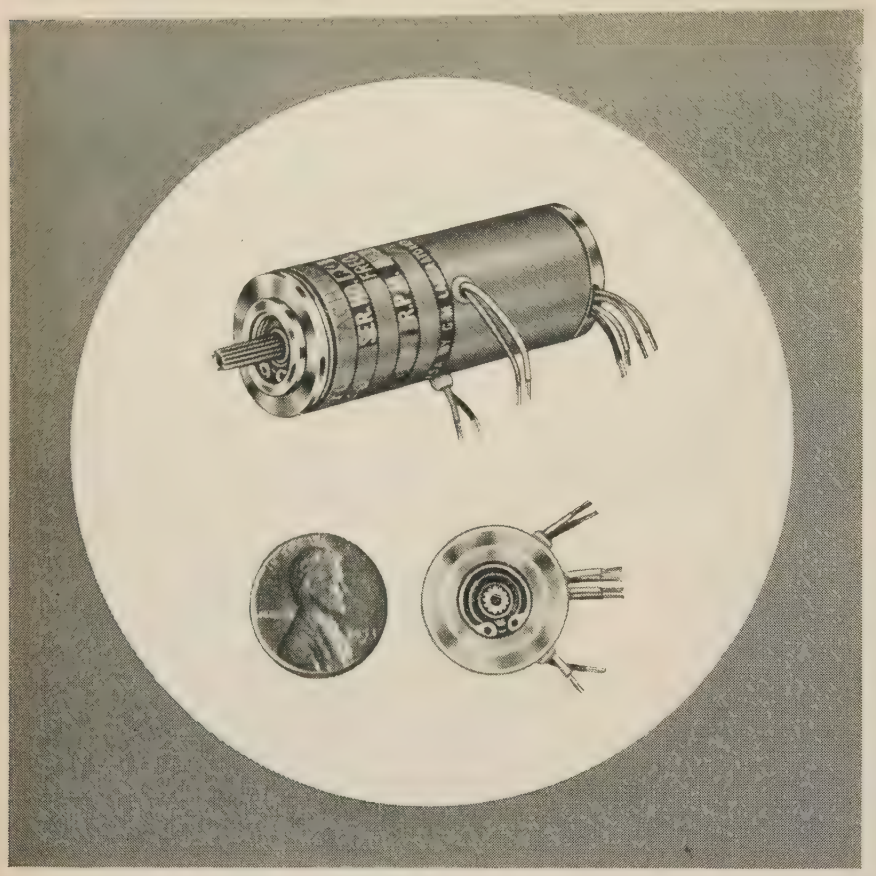
Spotlight on Space!



NEW G-M SIZE 8 MOTOR GENERATOR

for transistor operation

Tested to conform to all applicable Government Specifications for humidity, salt-spray, temperature, altitude, vibration! Promptly available in prototype and sample quantities.

- Outside Diameter: 0.750 inches.
- Weight: 2.9 ounces maximum.
- Tachometer-generator operates on 18 volts, 400 cycles.
- Gradient: 0.23 volts per 1000 RPM.
- Maximum null voltage: 0.015 RMS.
- Both fixed and control phase of motor wound for 18 volts, 400 cycles.
- Stall Torque: 0.3 ounce-inch, with no-load speed of 5400 RPM.
- Pinion Data: Precision Class 2, 13 tooth, 120 pitch, 20° pressure angle.

GM

G-M Servo Motors

manufactured by the Components Division of

G-M LABORATORIES INC.

4306 N. Knox Avenue • Chicago 41

Write for full information, G-M Recommended Procurement Specification No. 665 and Catalog.

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PRODUCT PREVIEW

TINY SWITCH withstands 700° F

This precision subminiature switch, designed for operation under high temperature conditions measures ¾" x 45/64" x 23/64" and is said to be "probably the smallest snap-acting high temperature switch available," according to **Haydon Switch, Inc., Dept. S/A, Waterbury 20, Conn.** Special refractory materials ensure stability of operating characteristics over the temperature range of −65° F. to 700° F.

Life at rated load is 25,000 cycles at 700° F. and 100,000 cycles at 450° F. Non-sealed, it is qualified to MIL-S-6743 and to the vibration requirements of MIL-E-5272A, Procedure II.

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ELASTOMER for high temperature

Designed for use at +400° F. with a wide variety of corrosive chemicals, synthetic fuels, and functional fluids, a highly-fluorinated synthetic elastomer is applicable in the fuel and hydraulic systems of aircraft and missiles, and in seals and liners in the automotive and chemical industries. Called "Fluorel," it chemically resists such fluids as diester, silicate ester, or petroleum-based lubricants and hydraulic fluids, JP-type aromatic fuels HEF or Hi Cal fuels, and powerful oxidants such as 90% hydrogen peroxide and red fuming nitric acid, according to **Minnesota Mining & Mfg. Co., Chemical Div., Dept. S/A, 900 Bush St., St. Paul 6, Minn.**

Can be compounded to meet USAF Mil-R-25897.

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LOX CYLINDER holds 3000 cu ft

This portable liquid oxygen cylinder LC-3 is now available to manufacturers of liquid oxygen. The cylinder is a double-walled, insulated container capable of holding a large volume of oxygen in the liquid state. It takes several days before enough heat leaks through to boil off enough gas for any to escape through the relief valve. In normal usage, the pressure inside is always above the setting of the delivery regulator and below that of the relief valve so that no gas is lost, says **Linde Co., Dept. S/A, Lexington Ave., New York 17, N.Y.**

There is a built in heat exchanger that automatically provides gas to a maximum of 300 cu ft/hr continuous service, or 1000 cu ft/hour in intermitent service. The LC-3 has a capacity (gaseous equivalent) of 3000 cu ft and weighs 493 lb. It is 58 in. high.

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more on page 262

COMPETITIVE PRESSURES AND RISING COSTS DEMAND GREATER PRODUCTION EFFICIENCY THAN EVER BEFORE

Have you ever wished you worked in a nice, quiet little shop...?

Sure you have.

The chances are you don't work in one now. There just aren't any nice, quiet little shops anymore. Everybody's out to make a buck. And they all seem to be competitors of yours.

Like everybody else's, your shop is full of complex equipment. Production is rough on the best of it. Eventual breakdown of some sort is almost inevitable. Even though your maintenance people can satisfy most of the problems, what happens when something goes wrong they can't handle?

With your production held up by a breakdown, you can't afford a vendor who passes the buck for service to all the suppliers of his components!

And what about that new equipment you're going to buy? Probably the latest in design. Most likely something your service people don't know anything about at all! Yet, it's got to get into production fast, and stay in as consistently as possible. With your production waiting, you can't afford to test and prove the vendor's machine for him!

Sciaky has always accepted *full responsibility* for its resistance welding and production equipment. Sciaky equipment is designed and built to do the job it was sold to do. That's why it's tested and proved *before shipment.* That's why the Sciaky Service Organization is on call anytime to service Sciaky equipment when necessary.

Why take less than the full advantage of consulting with a Sciaky Application Engineer the next time you're considering equipment. No obligation, of course.

Sciaky Service is a plus-feature that has been wanted by customers all over the world. Why take a chance on service that's sometimes needed on even the best machines. Why, to be sure, when you can enjoy the service facility that has been the difference between expensive production stoppages and minor delays.

SCIAKY

75A

SCIAKY BROS., INC., 4912 W. 67th STREET, CHICAGO 38, ILLINOIS • POrtsmouth 7-5600

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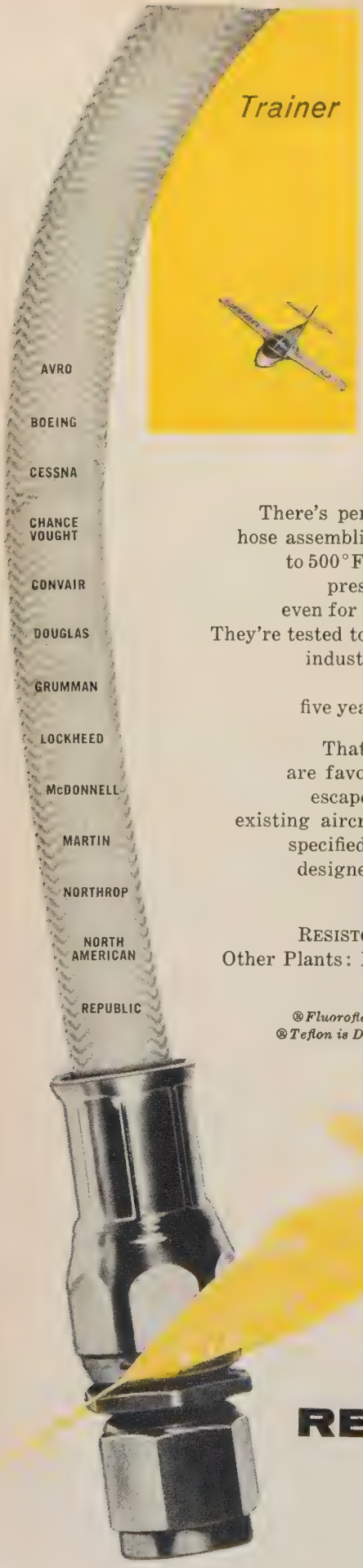

Trainer to X-15... and beyond

ALL fly with Fluoroflex®-T hose of Teflon®

There's performance to spare in Fluoroflex-T hose assemblies. High temperatures? They serve to 500°F . . . and beyond, in some cases. High pressures? They've passed rigid tests even for 4000 psi systems. Long impulse life? They're tested to 250,000 cycles . . . more than *double* industry standards. Optimum reliability? They've been flying for more than five years in jet and reciprocating aircraft.

That's why Fluoroflex-T hose assemblies are favored for fuel, lubrication, hydraulic, escape and fire control systems in so many existing aircraft. And that's why they're being specified for so many aircraft now being designed – they have performance to spare.

For data, write Department 306
RESISTOFLEX CORPORATION, Roseland, N. J.
Other Plants: Burbank, California; Dallas, Texas.

®Fluoroflex is a Resistoflex trademark, reg., U.S. pat. off.
®Teflon is DuPont's trademark for TFE fluorocarbon resins.

RESISTOFLEX

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TWO-WAY VALVE has independent controls

This two-way valve allows independently controlled flow in either or both directions. Available in standard IPS from ⅛" to ¾", the units are adaptable to hydraulic or pneumatic applications in pressures as high as 5000 PSI. The valves are female threaded to dryseal specifications and are available in brass, steel, aluminum, stainless, and special alloys. Extreme dependability, lower friction loss, and greater flow at all temperatures are claimed due to design which eliminates internal gaskets, springs, or hinged parts, says **True-Flow Valve Co., Dept. S/A, 79 Bow St., Everett 49, Mass.**

The units may be adjusted before, during, or after installation with a common screwdriver.

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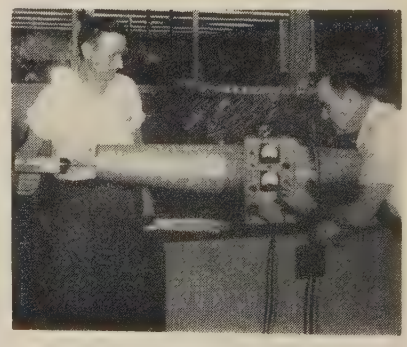
LEAK DETECTOR is super-sensitive



This super-sensitive instrument, a Halogen leak detector, finds leaks so small that it would take more than a year for 1/100 oz of gas to escape undetected, says **General Electric, Dept. S/A, Schenectady 5, N.Y.**

The leak detector consists of a new standard control unit and one of several probes. A tracer gas containing a halogen compound is introduced into the rocket engine system. The probe is passed over the external surface of the engine. Any escaping gas sets off an audible alarm and causes an electrical signal on the control unit. Detectors of this type are being used in rocket engine systems and other installed pressure or vacuum systems, it is said.

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more on page 264

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So can you. The versatile Mark II is an integrated oscillograph package—a readout tool for engineers and technicians everywhere . . . in the shop . . . in the lab . . . or in the field.

Just plug it in . . . put it to writing . . . anywhere.

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Recordings—Uniform, crisp, easily reproduced. Trouble-free ink writing on precision chart paper.

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Input—Differential; impedance 5 megs each side to ground.

Frequency Response—D.C. to 100 cps.

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SYSTEMS ENGINEERS

Openings are waiting for you at Autonetics in:

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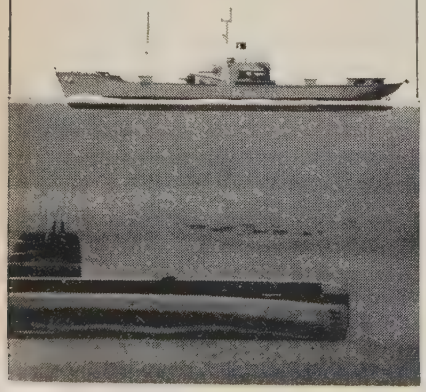

DIAPHRAGM SEALS use silicones, fabrics

These precision seals for aircraft, missiles, and other applications at temperatures ranging from −65° F. to 500° F., are special silicones compounded especially for diaphragm applications, says **Pacific Molded Products, Dept. S/A, 905 E. 59th St., Los Angeles 1, Calif.** They are combined with fabrics, such as Dacron and fiberglass, to provide precision diaphragms with virtual immunity to a broad spectrum of chemical and physical environments, it is claimed.

Produced to customer's requirements, the diaphragms retain their shape and "resist deterioration, provide outstanding performance over a long service life," according to the company.

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SYNCHROS have 3-min accuracies

Available from production in its line of R900 Series Synchros are these size 11 components, the newest of which are units having a maximum error from electrical zero of three minutes. They have been designed for high accuracy, says **Kearfott Co., Inc., Dept. S/A, 1378 Main Ave., Clifton, N.J.**

Outstanding features claimed for these units are: all standard units have stainless steel bearings, shafts, and housings; all are mechanically stable, positively grounded and shielded; all have been dimensionally standardized, (except for shaft dimensions); both low and high impedance models are available in all types.

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FILTERS offer wide media choice

The Palmer-Parmatic liquid filters have been designed to give maximum performance within a given envelope and weight in aircraft applications, says **Palmer Aero Products, Ltd., Dept. S/A, Herga House, Vincent Sq., London, S.W.1, England.** Standard types have a normal range of −55 to +200 deg C and an operating pressure of up to 6000 psi.

Any type of filter media, including sintered wire or metal, felt, paper, or synthetics may be obtained, and the degree of filtration is said to be sufficient to suit any known requirement and a virtually unlimited range of fluids. A typical unit, the Model D1021, has a flow capacity of seven gals, imperial, at 3000 psi, and the filtration rating is five microns absolute. Pressure drop through the complete filter is 15 psi at 35 deg C.

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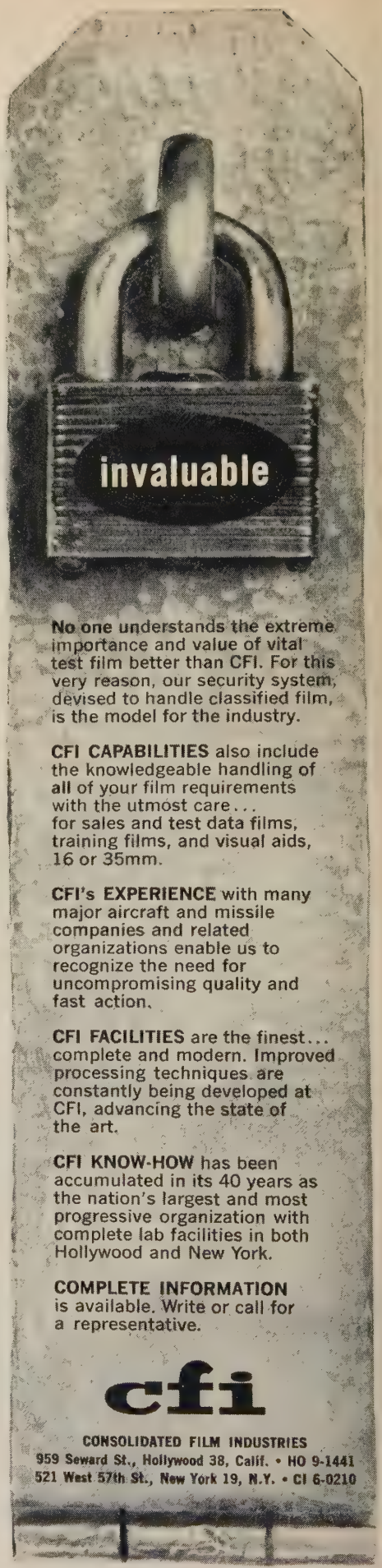

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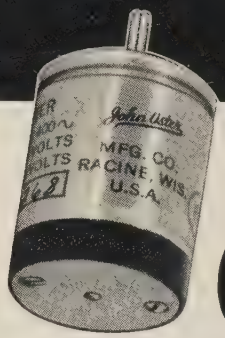
100 "G" SYNCHRO

Uniquely Designed to Withstand 100 "G" Shock Test...20 "G" Vibration Test from 10 to 2500 Cycles...20 "G" Acceleration Test...

BURTON BROWNE ADVERTISING

- −55°C to +85°C temperature range. Higher if desired.
- 26V rotor excitation.
- .210 amps, 2 watt.
- 40 millivolts null voltage.
- 11.8 ± .5V max. stator output voltage.
- 35 + J145 rotor impedance.
- Withstands 10 lbs. lead pull test.
- Aluminum housing.

A complete line of synchros in sizes 8, 10, 11 and 15 is offered for your CX, CDX, CT, TX, TDX, TR and RS applications.



Type 4073-07.

Oster®

Other Oster Synchros For Hi Temp Applications

Distinctive Oster features such as stainless steel housing and temperature stabilization are available for hi temp units.

You are invited to consult Oster engineers on your synchro requirements.

OTHER PRODUCTS INCLUDE:

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Engineers For Advanced Projects: Interesting, varied work on designing transistor circuits and servo mechanisms. Contact Mr. Robert Burns, Personnel Manager, in confidence.

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...fail-safe overheat protection

NEW miniature, hermetically sealed, single-shot, temperature-sensitive switch provides FUNCTIONAL RELIABILITY for positive over-temperature protection. Factory preset within 1% of specified temperature.

TEMPERATURE RANGE: +113° F. to +1500° F.
CURRENT RANGE: 10 to 500 Amperes
SPST Normally open or closed types.

Patents Pending

Write for new Brochure containing complete specifications:
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thermocal

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SANTA MONICA, CALIFORNIA

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ACCELEROMETER weighs four ounces

This new sub-miniature accelerometer with potentiometer pickoff, the LA29-0100 series, is only one inch in diameter, less than 1½ in. long, and weighs about four ounces, says **Humphrey, Inc., Dept. S/A, 2805 Canon St., San Diego, Calif.**

The unit is an hermetically sealed, dry-gas filled instrument. Performance is said to be practically unaffected by temperatures ranging from —75 to +200 deg F; satisfactory performance may be obtained at temperatures to 400 deg F. It is available in a variety of acceleration ranges and potentiometer characteristics.

Write in No. 338 on Reader Service Card

CONTROL VALVE for fluid fuels

This motorized Flexbelt valve controls the flow of fluid fuels for missiles and rockets. Flow is modulated by a belt covering or uncovering orifices in the valve seat. The belt is moved across the valve seat by a drum which is driven through a gear train by a two-phase servo motor. Valve opening information is transmitted to a remote point by a potentiometer, says **Consolidated Controls Corp., Dept. S/A, 750 South Isis Ave., Inglewood, Calif.**

Standard valves are available with flows to 200 gpm with 600 psi pressure drop. Speed of operation from full open to full closed (or vice versa) is from 0.5 to six seconds, depending on gear ratio and motor power. Potentiometers to drive instruments are available with resistances to 10,000 ohms at two watts. Weight of the unit is 4½ lb.

Write in No. 339 on Reader Service Card

SWITCHES for high current

A new line of small, snap-action precision switches, Hetherington S2A Series, for manual and mechanically-actuated electrical and electronic uses are rated at 20 amperes, 125/250 V ac. The series features accurately controlled movement and force characteristics that afford excellent repeatability in critical applications, says **Hetherington Inc., Dept. S/A, Folcroft, Pa.**

Of particular note is the design of the ammonia-free phenolic case. This design enables the switch to withstand excessive actuating pressures without damaging the blade, contacts, or case and prevents case distortion caused by undue mounting screw pressures. The switches are available with any of eight actuator mechanisms.

Write in No. 340 on Reader Service Card

more on next page

NOW..

HIGH PRESSURE HOSE FOR AIRCRAFT AND MISSILES

STRATOFLEX

SUPER "T-HP"

Teflon* HOSE

with medium pressure "SUPER-T" RELIABILITY

Withstands tests more severe than MIL-H-8788

- High Temperature Spectrum tests exceed MIL-H-8788 in both impulse and temperature requirements and fully qualified to ARP 604.
- Positive lock fitting through elimination of socket hex.
- Available with swivel elbows that can be rotated without disturbing the wire grip lock.
- Stratoflex High Pressure Fitting combines the exclusive Pressure Activated Gland Seal and the assurance of crimp design.
- Shelf life practically unlimited.
- Available in two styles of high temperature fittings. Combination of stainless steel and carbon steel, or corrosion resistant all stainless steel fittings.

Hose assemblies are factory assembled from stock with straight, 45° and 90° fittings. Other angles or connections are made to your specifications. WRITE FOR BULLETIN S-7 TODAY!

*Teflon is a registered DuPont trademark

SF7-9

STRATOFLEX Inc.

P.O. Box 10398 • Fort Worth, Texas
Branch Plants: Los Angeles, Fort Wayne, Toronto
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Pittsburgh
San Francisco, Seattle
Toronto, Tulsa

Write in No. 197 on Reader Service Card at start of Product Preview Section

COMMUTATOR for PAM systems

This 3-pole, 28-V dc ungoverned motor-driven telemetering commutator is used in pulse modulation systems with either airborne or ground gating. Each of the 3 poles contains a flexible master pulse which can be externally interconnected to provide either a pulse of 2 live segments and 3 dead segments or 3 live segments and 4 dead segments, says **Instrument Development Laboratories, Inc., Dept. S/A, 67 Mechanic St., Attleboro, Mass.**

Power is provided by a radio-noise-filtered, ungoverned dc motor which rotates the brushes at 10 rps through an IDL gear reduction system. One pole has a 50 per cent duty cycle, the other two have 70-30 per cent duty cycles.

Write in No. 344 on Reader Service Card

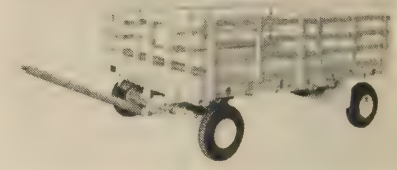
TEST LOADER follows any schedule

This Hydraulic Test - Loading Equipment consists mainly of a controller for the translation of graphic data into electrical analogs and an electro-hydraulic servo valve for controlling a hydraulic loading actuator in accordance with the input data. The control system will follow any cyclic or irregular loading schedule within the capability of the hydraulic system. It is designed for both single and multiple channel operation as required, says **Research, Inc., Dept. S/A, 115 N. Buchanan, Hopkins, Minn.**

Manual controls are provided on each channel for setting in any static reference load level upon which the variable load program is superimposed, adjusting the relative amplitude of the programmed loads, setting a limit on the rate of load application, and adjusting the system gain.

Write in No. 345 on Reader Service Card

TRAILER is versatile

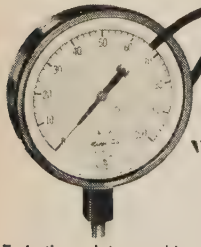


This Atomic Bomb Trailer, MHR-12/M, is multi-purpose and versatile. There are no problems of component accessibility for repairs maintenance. It will support a normal load of 4,000 lb. The all aluminum construction makes this unit suitable for air transportable as well as dropable. The adaptors are capable of supporting all other varieties of bombs, missiles and miscellaneous stores, says **United Mfg. Co., Dept. S/A, 5250 Dobeckmun Ave., Cleveland 2, Ohio.**

There are 48 rotating tie-down rings; five tool boxes; air hydraulic brake and automatic breakaway brake; telescopic aluminum drawbar; air springs; removable stake racks; hinged hatchways; hand parking brake and retractable storage legs.

Write in No. 346 on Reader Service Card

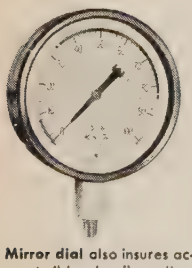
more on page 270



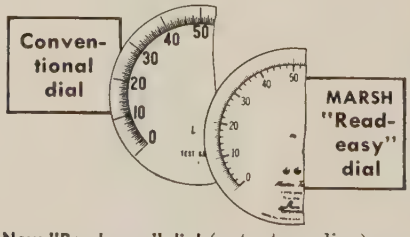
New MARSH "Master-Test" SERIES

Twin-tip pointer enables observer to read "dead-on" by lining up twin tips like gun sight.

Unprecedented accuracy and dependability in test gauges developed to meet today's exacting requirements. Each gauge individually *dead-weight tested!* Guaranteed accurate within ¼ of 1% plus or minus of maximum dial reading over entire range.

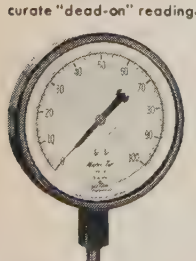


Mirror dial also insures accurate "dead-on" reading.



New "Read-easy" dial (patent pending), as illustrated above, assures reading accuracy in keeping with indicating accuracy. Also note three advanced means of reading available in all "Master-test" gauges: twin-tip pointer, mirror dial, and "non-parallax" dial as shown opposite.

Sizes 4½", 6", 8". All standard pressure ranges 0-15 psi to 0-30,000 psi, vacuum and compound.



"Non-parallax" dial has Plexiglas insert that assures accurate reading even when read at angle.

Ask for new 20 page bulletin covering all details

MARSH INSTRUMENT CO., Dept. 43 Skokie, Ill.
Division of Colorado Oil and Gas Corporation
Marsh Instrument & Valve Co., (Canada) Ltd.
8407 103rd St., Edmonton, Alberta, Canada
Houston Branch Plant, 1121 Rothwell St., Sect. 15, Houston, Texas

Write in No. 198 on Reader Service Card

GABB FC-3500

MODEL NO.	TANK OPENING	O.D.	WEIGHT POUNDS	TYPICAL SERVICE	APPLICATIONS
FC-3510	1.5"	2.09"	.31	Synthetic oil	Military and Commercial Hydraulic Reservoirs
FC-3520	2.00"	2.80"	.69	Hydraulic oil	Military and Commercial Hydraulic Reservoirs
FC-3500	3.00"	3.75"	.80	Fuel, engine oil, water-alcohol	Military and Commercial Fuselage and Wing Tanks
37-3530	3.00"	3.75"	.719	Fuel, water-alcohol	Military and Commercial Fuselage, Wing and Drop Tanks, Fire Bombs
FC-3700	3.00"	3.47"	.456	Fuel, water-alcohol	Military Fuel Tanks
FC-4000	4.00"	4.62"	1.97	Fuel	Commercial Fuselage and Wing Tanks

The Gabb Adapter and Cap Unit, Tank Filler, is the first 3 inch assembly to successfully pass all the requirements of specification of MIL-C-7244 B (ASG). It is applicable to fuel, oil, water-alcohol and hydraulic reservoirs. This self-contained, flush mounted unit permits tank pressure relief by means of a lever action handle prior to removal of the cap from its adapter. Subsequent removal of the cap requires only a 35° rotation of the same handle. Write for free brochure No. 435.

GABB SPECIAL PRODUCTS Inc.
WINDSOR LOCKS, CONN.

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Wherever reliability is vital...
you'll find **BARDEN PRECISION** ball bearings

Barden Precision ball bearings are basic components in the instruments and mechanisms that meet today's toughest requirements for systems reliability. You'll find them in navigation and flight instruments...in guidance and control systems...in computers, turbo-driven equipment and ground support instrumentation...wherever reliability is vital.

When you need top bearing performance, Barden provides it with functionally tested bearings of uniform quality—standard or special—for prototypes or extended production runs. Because Barden is exclusively a producer of highest precision ball bearings, you get the full benefit of its specialized design, manufacturing and application experience.

The complete Barden line includes bearing sizes from .0469″ bore to over 3″ O.D., all produced to Barden Precision standards of dimensional accuracy, uniformity and reliability. Write for catalog and bearing selection guide.

for reliability...specify **BARDEN PRECISION BALL BEARINGS**

THE BARDEN CORPORATION, 75 East Franklin St., Danbury, Connecticut
Western office: 3850 Wilshire Boulevard, Los Angeles 5, California.

Write in No. 200 on Reader Service Card at start of Product Preview Section

The CHATILLON Running Torque Tester & Dynamometer is the FASTEST MOST ACCURATE MOST ECONOMICAL way to test fractional H.P. motors!

NOW available with a decade counter tachometer system for accuracy to ± .1% of actual speed, plus ± 1 count.

OUTSTANDING FEATURES:

- **Torque Capacities** range from .1 oz. in. to 24 lb. ft.
- **Speed Range** up to 50,000 RPM
- **Power Dissipation** varies from:
  Continuous—.013 H.P. to 4 H.P.
  ½ hour—.025 H.P. to 8 H.P.
  15 minutes—.05 H.P. to 16 H.P.
- **Tachometer Accuracy:**
  1% of full scale with electric tachometer.
  ± .1% of actual speed plus ± 1 count with decade counter tachometer system.
- **Temperature Compensated Springs**
  Made of Chatillon Iso-Elastic® material
- **Automatic Overload Protection**

Special Units designed to meet specifications.

SINCE CHATILLON 1835

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85 CLIFF STREET, NEW YORK 38, N.Y.

Manufacturers of Scales, Force Measuring Instruments and Precision Springs Since 1835

Circle in No. 201 on Reader Service Card

DUAL-BEAM OSCILLOSCOPE for display of x-y plots

Type 411 dual-beam oscilloscope has exceptional sensitivity and is capable of displaying x-y plots and simultaneous display of either the x- or y-signals against time, says **Allen B. Du Mont Laboratories, Inc., Dept. S/A, 760 Bloomfield Ave., Clifton, N.J.** The instrument can develop 9 major modes of display. By adding z-axis modulation, 27 addition modes are possible.

Expanded and calibrated sweeps may be independently positioned while being displayed at the same time. Each amplifier has 1 mv full-scale sensitivity. The frequency response of the instrument extends from dc to beyond 100 kc and the amplitude range varies from 1 mv to 580 V in 17 steps.

Write in No. 347 on Reader Service Card

THERMOCOUPLES for rugged service

The Con-P-Pak thermocouples are suitable for service in a variety of exacting applications, says **Continental Sensing, Inc., Dept. S/A, 1950 N. Ruby St., Melrose Park, Ill.** Metal combinations are available for ranges of —300 to +600, 75 to 1200, and 1000 to 1600 deg F; rhodium platinum is used for temperatures over 1600 deg F.

The thermocouple conductors are encased in specially processed ceramics and surrounded by chemically clean metal sheaths. Various junctions and tips are available, along with several types of connectors. Insulation resistance between wires and sheath ranges up to 100 megohms at 500 V dc. Dielectric strengths extend to 2000 V ac.

Write in No. 348 on Reader Service Card

VHF AMPLIFIER rated at 20 kw

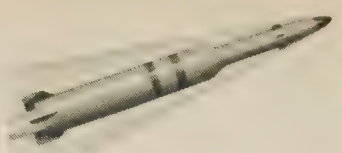
The type HS 201 air cooled VHF amplifier is a 20-kw device that is being used in transmitters for point-to-point communication service based on ionospheric forward-scatter transmission, says **Marconi's Wireless Telegraph Co., Ltd., Dept. S/A, Marconi House, Chelmsford, England.** In this application, two amplifiers are normally operated in parallel, each of them feeding directly into one half of a symmetrical antenna array.

The amplifier consists of a power iary rectifier unit, and an RF unit. control unit, a rectifier unit, an auxil- The frequency range is 35 to 55 mc and output impedance is 50 ohms. When used with the proper drive and phasing equipment, the amplifier can attain a frequency stability of five parts in 106 for a temperature change of ten deg C.

Write in No. 349 on Reader Service Card

more on next page

ELECTRONICS: Over, on and under...



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Autonetics offers exceptional opportunities to graduate engineers in EE, Physics, or ME, who are experienced in:

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Logistic Support of Inertial Guidance Systems

Automatic Checkout Centrals

Armament Control Systems

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Opportunities exist for both in-plant and field assignments (liberal per diem).

The time never has been better to make your move to Autonetics. Within the next few years our Military Logistics Department will expand to more than five times its present size. You'll receive interesting assignments, excellent per diem, and fringe benefits, and immediately will step into a position with the potential for advancement you have always hoped for.

Send your resume to:
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Manager, Employment Services, Dept. D-95
9150 East Imperial Highway
Downey, California

Autonetics
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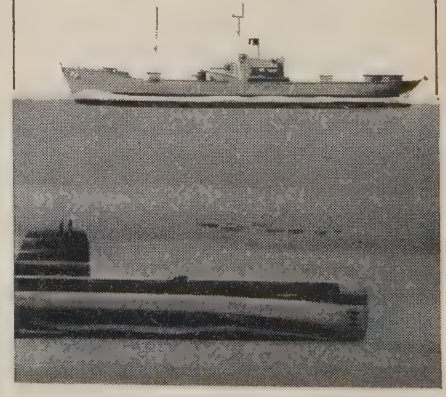
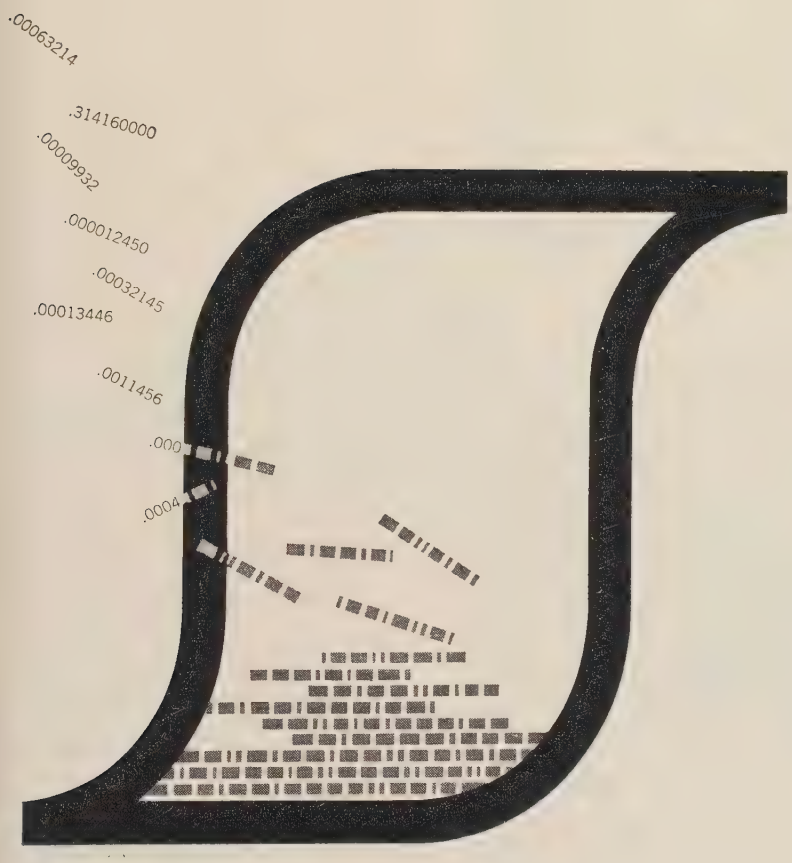


Check Employment Inquiry Form on Page 183

TAPING CRITICAL INFORMATION?

"SCOTCH" Brand high potency oxides let you pack more bits per inch!

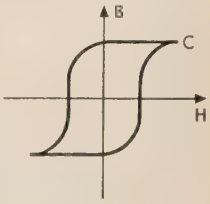


Every day SCOTCH Brand High Resolution Tapes are getting the nod for more instrumentation jobs. The reason? Performance. In taping high frequency data, the sharper resolution lets you pack more pulses to the inch—a greater density of information to each foot of tape.

At the root of this advance are the high potency oxides used in the magnetic coating. The higher magnetic retentivity of these oxides—about a third more than standard—offers distinct advantages. It permits the use of a thinner magnetic coating which may be combined with a thinner polyester base. Naturally, this means a more flexible tape — one that conforms for more intimate tape-to-head contact, automatically improving resolution in the taping of high frequencies.

Even so, you don't have to sacrifice output in low frequencies. For in addition to the marked increase in sensitivity to short wave lengths, SCOTCH Brand High Resolution Tapes show some increase in sensitivity even to long wave lengths.

These more flexible tapes cut drop-outs, too. With better tape-to-head contact, there's less chance that a stray bit of dust can sneak between tape and head to cause a drop-out. The superior magnetic properties of SCOTCH Brand High Resolution Tape No. 159 show up in oscilloscope tests—producing a good squared-up hysteresis curve like that shown at the right, and symbolically illustrated at the left.



Whatever your application—data acquisition, reduction or control programming—you can count on SCOTCH Brand technology to create tapes of higher uniformity and reliability for error-free performance.

SCOTCH Brand High Output Tape No. 128 provides the sensitivity for good output in low frequencies, even under extremes of ambient temperature. SCOTCH Brand Sandwich Tapes No. 188 and 189 offer extremely long life and reduced head wear in digital work and many AM, FM and PDM applications. Finally, for top performance at low cost per foot, SCOTCH Brand Instrumentation Tapes No. 108 and 109 remain the standard for the industry.

Where there's no margin for error, there's no tape like SCOTCH Brand. For more details, mail the reader inquiry card or write Magnetic Products Div., 3M Company, St. Paul 6, Minnesota.

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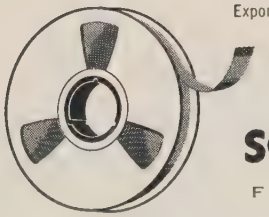


SCOTCH BRAND MAGNETIC TAPE

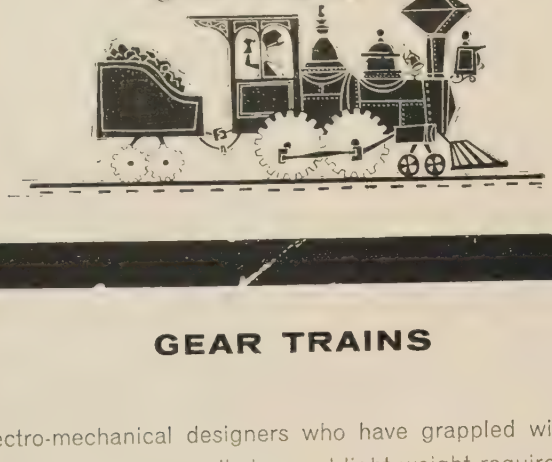
FOR INSTRUMENTATION

MINNESOTA MINING AND MANUFACTURING COMPANY
...WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

3M's Missile Industry Liaison translates your problems to 3M specialists in your field of interest. Write for free brochure.

Write in No. 202 on Reader Service Card at start of Product Preview Section



GEAR TRAINS

Electro-mechanical designers who have grappled with the extreme accuracy, small size, and light weight requirements of gear trains used in Inertial Guidance and Controls should write to Mr. C. T. Petrie, Research & Engineering Staff.

LITTON INDUSTRIES Electronic Equipments Division
Beverly Hills, California

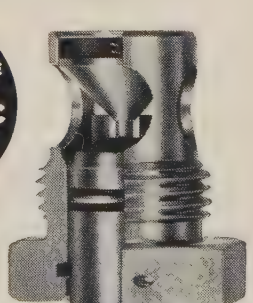
Just a twist of the wrist...

FOR CHIP INSPECTION—

NO WIRES • NO TOOLS • NO DRAIN PANS...

Tedeco Bayonet Type Self-Closing Magnetic Drain Plugs make routine inspection easy. An inward push and slight turn removes plug. Valve closes automatically. For drain or refill, bayonet connection hose available.

TEDECO BAYONET TYPE SELF-CLOSING MAGNETIC DRAIN PLUG



WRITE FOR FURTHER INFORMATION

TECHNICAL DEVELOPMENT CO.
Glenolden, Pa. — Ludlow 3-3330

Write in No. 203 on Reader Service Card

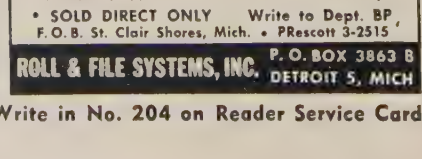
QUICK, FILING AND WITHDRAWAL

Depth	11¼"	22¼"	30½"	36½"	42¼"
49 Tube 1¾" I.D.	49AB $7.50	49CD $9.50	4930 $12.80	4936 $13.80	4942 $14.80
MODEL 25 Tube 2¼" I.D.	25AB $7.00	25CD $9.00	2530 $11.80	2536 $12.80	2542 $13.80

Shipping Weight

Model 49	8 lbs.	12 lbs.	15 lbs.	18 lbs.	20 lbs.
Model 25	6 lbs.	10 lbs.	13 lbs.	15 lbs.	17 lbs.

ENAMELED DARK GREEN OR MED. GRAY - State Color



JR 36
Designed to Mount Under Board—Mounting Brackets Furnished. Gray Only.

9.50 SET of TWO

Sold in Sets Only—2 JR36 Per Set

8 lbs. Ship. Wt.

• SOLD DIRECT ONLY Write to Dept. BP, F. O. B. St. Clair Shores, Mich. • PRescott 3-2515

ROLL & FILE SYSTEMS, INC. P. O. BOX 3863 B DETROIT 5, MICH

Write in No. 204 on Reader Service Card

TIME INDICATOR is subminiature

Th's new subminiature elapsed time indicator, type WT-1, is one inch in diameter and less than two inches long. It weighs three ounces and is the lightest time indicator now available, says **Waltham Precision Instrument Corp., Dept. S/A, Waltham, Mass.** It can be used in almost any application where operational time of critical equipment is needed. It will record up to 10,000 hours, permitting numerous applications in measuring the time of operation of engines and control components in aircraft and missiles.

The indicator operates on 115 V and can be supplied for either 60 or 400 cps frequency. It meets MIL-E-5272A.

Write in No. 352 on Reader Service Card

PRESSURE VALVE for use to 350 deg F

This new MC 3622-1 Pressure Reducing Valve features an integral relief valve and operates in temperatures from +350 to —35 deg F. When 333 to 3000 psi pressure is applied at the inlet port, pressure at the outlet port is maintained at 266 to 315 psi. An integral relief valve prevents the buildup of dangerous overpressures at the outlet port of the valve, says **M. C. Mfg. Co., Dept. S/A, Lake Orion, Mich.**

A feature of the valve is said to be a porous stainless steel filter positioned in the inlet, that precludes the possibility of foreign material entering the valve and damaging the highly polished valve seats, or preventing them from operating properly.

Write in No. 353 on Reader Service Card

VOLTAGE REGULATOR has wide frequency range

This ac line voltage regulator for ground support and airborne equipment features wide frequency ranges. The model LVR-150 is housed in a steel case and encapsulated in epoxy for vibration and shock characteristics, says **Kavamil Co., Dept. S/A, 1417 W. El Segundo Blvd., Compton, Calif.** It is stud-mounted with 4-pin connector. Size is 7" x 7" x 6". Weight about 15 lbs, and available in lighter weights for airborne equipment.

Electrical characteristics include: input voltage, 90-135 VAC; output voltage, 115 V ±1% for input of 90-135V; frequency range, 50-65 cps (also available for 400 cps); response time, approx. 100 milliseconds: rating, 150 VA (available from 50 VA to 2.5 KVA).

Write in No. 354 on Reader Service Card

more on page 274

The NEW Bruel & Kjaer

TRUE RMS ELECTRONIC VOLTMETER

* Measures 20 db Dynamic Range Accurately
* Reads Out in True RMS, Average, or Peak Values

The Model 2409 Electronic Voltmeter

covers the frequency range 2 to 200,000 c/s ± 0.2 db

- ★ **Measures full scale complex signals with a crest factor of 5.**
- ★ **Zener diode calibration reference**
- ★ **Calibrated decade amplifier**
- ★ **Cathode follower input and output**

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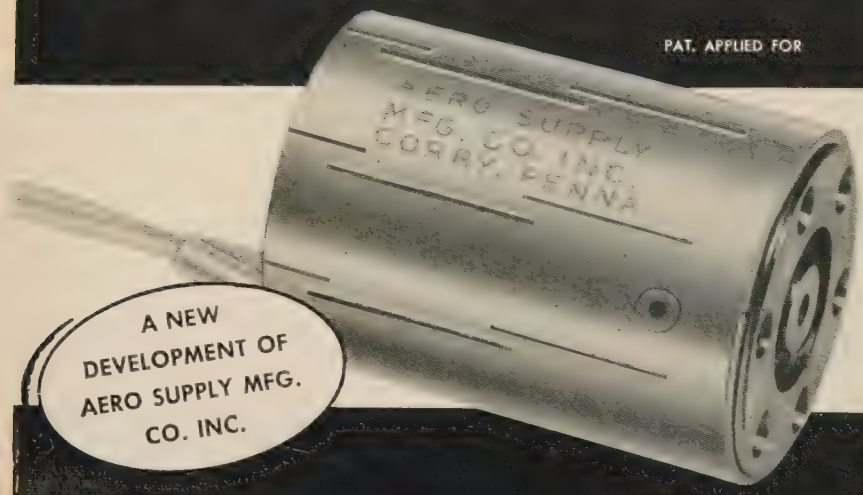
400 CYCLE
NON-RECTIFIED
AC SOLENOID VALVE

PAT. APPLIED FOR



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SHOWN TWICE ACTUAL SIZE

AERO SUPPLY ACCEPTED A CHALLENGE THAT 92 OTHER MANUFACTURERS TURNED DOWN . . . THE CREATION OF A DIRECT ACTING 400 CYCLE NON-RECTIFIED AC SOLENOID VALVE FOR A MOST UNUSUAL APPLICATION INVOLVING WEIGHT REDUCTION AND RELIABILITY.

Aero Supply has designed and built a 400 cycle non-rectified AC solenoid valve for precision high temperature operation or for immersion in JP-6 fuel. While this valve is designed for one specific application, Aero Supply has established capability in this area and is prepared to design and manufacture other 400 cycle non-rectified solenoids/valves to meet your specification. Request Bulletin #59-130 and our Capabilities Report.

ENGINEERS WANTED . . . If you would like to join a growing dynamic creative organization, send your resume to our Chief Engineer.

AERO SUPPLY MFG. CO. INC.
CORRY, PENNSYLVANIA
ELECTRO-MECHANICAL DEVICES • ENGINEERED FLUID CONTROL SYSTEMS • PRECISION MANUFACTURING

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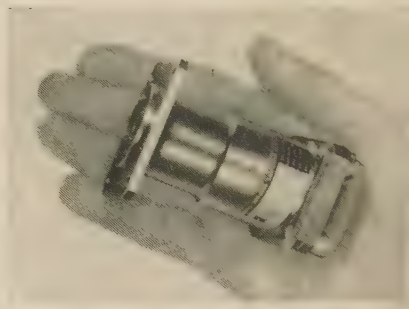
PUMP-MOTOR *has high-speed design*

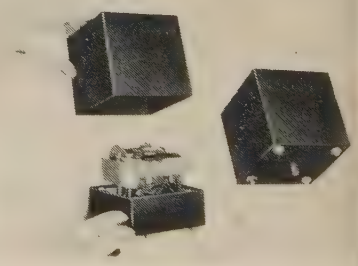


The Model 013685 Hummingbird hydraulic pump-motor for aircraft and missile installations attains standards of speed, reliability, and endurance unique in a unit only 4.125 in. long, says **Pesco Products Div., Borg-Warner Corp., Dept. S/A, 24700 N. Miles Rd., Bedford, O.** The 1.1-lb piston-type device is rated for 24,000 prm and delivers 2.5 gpm at 3000 psi.

It features spherical piston rings, all-metal O-rings and seals, a constant velocity joint, and all-steel construction. It will operate with fluids from —65 to +550 deg F. It requires no modification or adjustment for installation as a pump or as a motor, and it may be run directly from high-speed turbines or similar drives.

Write in No. 355 on Reader Service Card

MAGNETIC SHIELDS *permit lower cost*



A new Netic Co-Netic magnetic shield that permits lower cost shaded pole motors to be used in many servo and other instrumentation applications which formerly required more expensive components, says **Magnetic Shield Div., Perfection Mica Co., Dept. S/A, 1322 N. Elston Ave., Chicago 22, Ill.** With proper grounding, effective electrostatic shielding is also accomplished, it is claimed.

The shield is said to reduce the radiated field to under five gauss thereby aiding miniaturization by permitting sensitive magnetic components to be positioned in close proximity. It is non-shock sensitive, non-retentive and structurally rugged for mounting.

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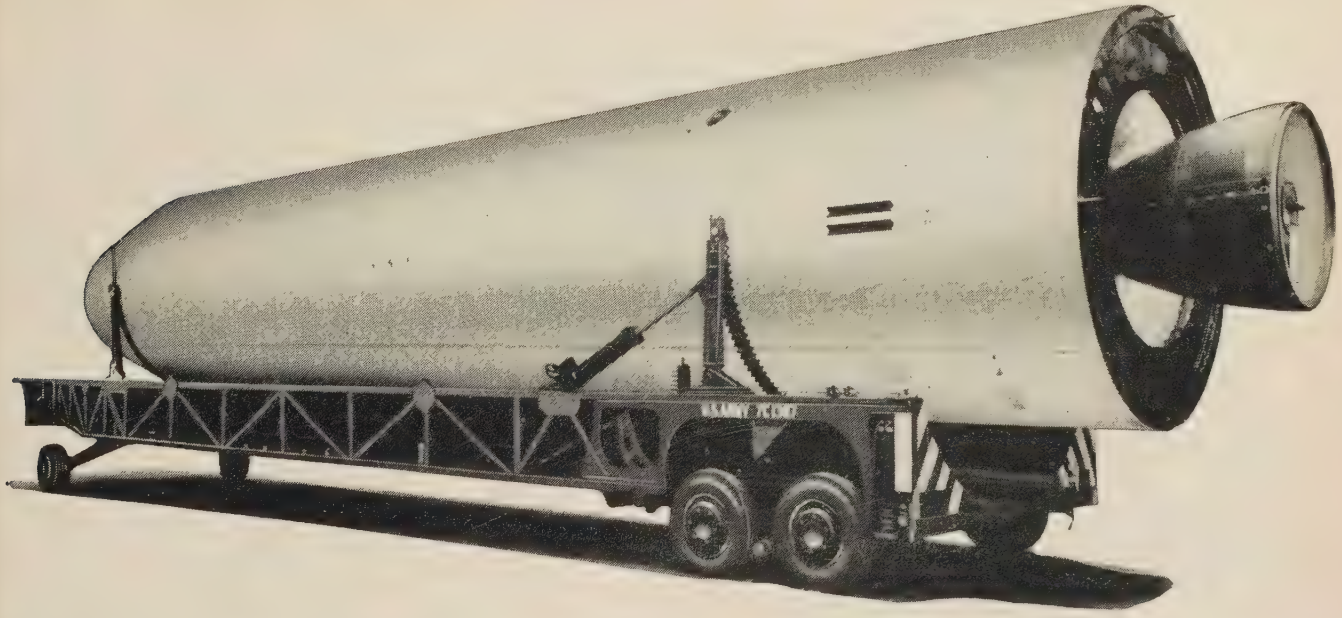
more on page 276

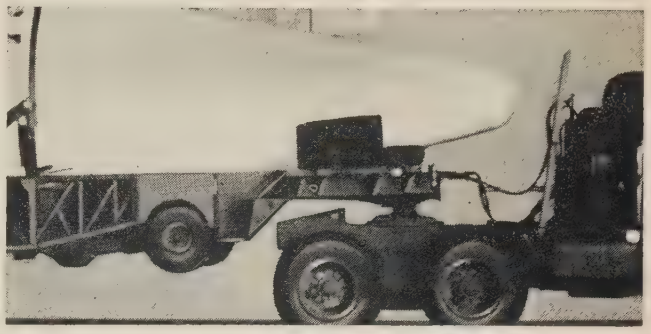
FRUEHAUF IS A DEPENDABLE SOURCE OF **IDEAS AND PRODUCTS** FOR DEFENSE



Most Efficient Supplier of Ground Handling Equipment For Today's Modern Space Age!

From World War II days to our present space age Fruehauf has been an active leader in the research, design, and development of the multitude of rapidly changing ground handling vehicles demanded by the military. Among the most recent of these is the Jupiter Transporter, shown above, which is the result of close teamwork between engineers at Fruehauf and Chrysler Corporation, prime contractor for the Jupiter.

Fruehauf's unsurpassed experience in both commercial and military ground transportation makes them the logical choice when ground handling equipment problems arise. As the world's leading builder of commercial Trailers, Fruehauf has pioneered in the research, design and production of containers or transporters for many types of missiles . . . shelters for mobile radar and electronic equipment . . . specialized Tank-Trailers for standard and exotic fuels . . . powder haul vans . . . mobile containers for materials and supplies . . . as well as over 400 different types of other military vehicles.



At Fruehauf are engineers and designers who have met and solved practically every type of problem in space age ground transportation. You'll find modern, diversified Fruehauf manufacturing plants all across the nation, with automated production lines equipped with advanced, precision machinery.

When your military contract involves ground handling equipment, why don't you consult Fruehauf? No one is better equipped, or more qualified, to help you solve these problems.

MILITARY EQUIPMENT DIVISION

FRUEHAUF TRAILER COMPANY

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Sikorsky technician peels a lamination from a 5" diameter Shim designed for tail take-off assembly.

At Sikorsky, as at most other leading manufacturers of aircraft and missiles, laminated Shims of LAMINUM insure assembly of components with no margin for error. Shims of LAMINUM, which peel for a thousandth fit right at the job, always deliver a 3-fold advantage: they save time, improve quality and cut costs.

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ACCELEROMETER is seismic mass systems

This accelerometer, type TA2, is a seismic mass system that possesses low cross sensitivity because of tranverse stiffness of the self-compensating E springs. It is totally immersed in a silicone fluid with a viscosity selected to provide a damping ratio of 0.65. Volumetric changes in the oil with temperature rise are compensated by expansion chambers in the case. This allows an operating temperature range from −40 deg to +100 deg C, says **Lind Corp., Dept. S/A, Research Park, Princeton, N.J.**

Dual pots are provided for high level, redundant output. Life tests reveal that units can stand ten million reversals without affecting the calibration.

Write in No. 357 on Reader Service Card

VOLTAGE REGULATORS are heavy-duty

These heavy-duty electromechanical ac voltage regulators, Selenivac, are designed for 25, 50, 60 or 400 cycle operation and provide ±1 per cent control with no waveform distortion. Input voltages may be one-phase, two-phase three or four wire and three-phase. They are unaffected by line or system power factor, says **American Rectifier Corp., Dept. S/A, 95 Lafayette St., New York 13, N.Y.**

The Selenivac is primarily intended for applications where large quantities of regulated power are needed. A switch permits either manual or automatic opration. Ratings are from one to 300 kva and any input or output voltage up to 600 V. Response time is about five V per second.

Write in No. 358 on Reader Service Card

POWER CONVERSION uses systems approach

This frequency converting system consists of two 50 kw motor-generator sets with a 60 cycle input and 400 cycle output, together with a control panel containing generator controls and push buttons for the motor starter which is separately located. The motor-generator operates at 1714 rpm and is induction motor driven. The 400 cycle output voltage is controlled by a Kato Regociter static exciter and magnetic amplifier voltage regulator unit. This is a static device which eliminates the conventional rotating exciter and the electro-mechanical type of regulator, says **Kato Engineering Co., Dept. S/A, Mankato, Minn.**

The systems approach to power conversion offers, it is claimed, important advantages over improvised systems.

Write in No. 359 on Reader Service Card

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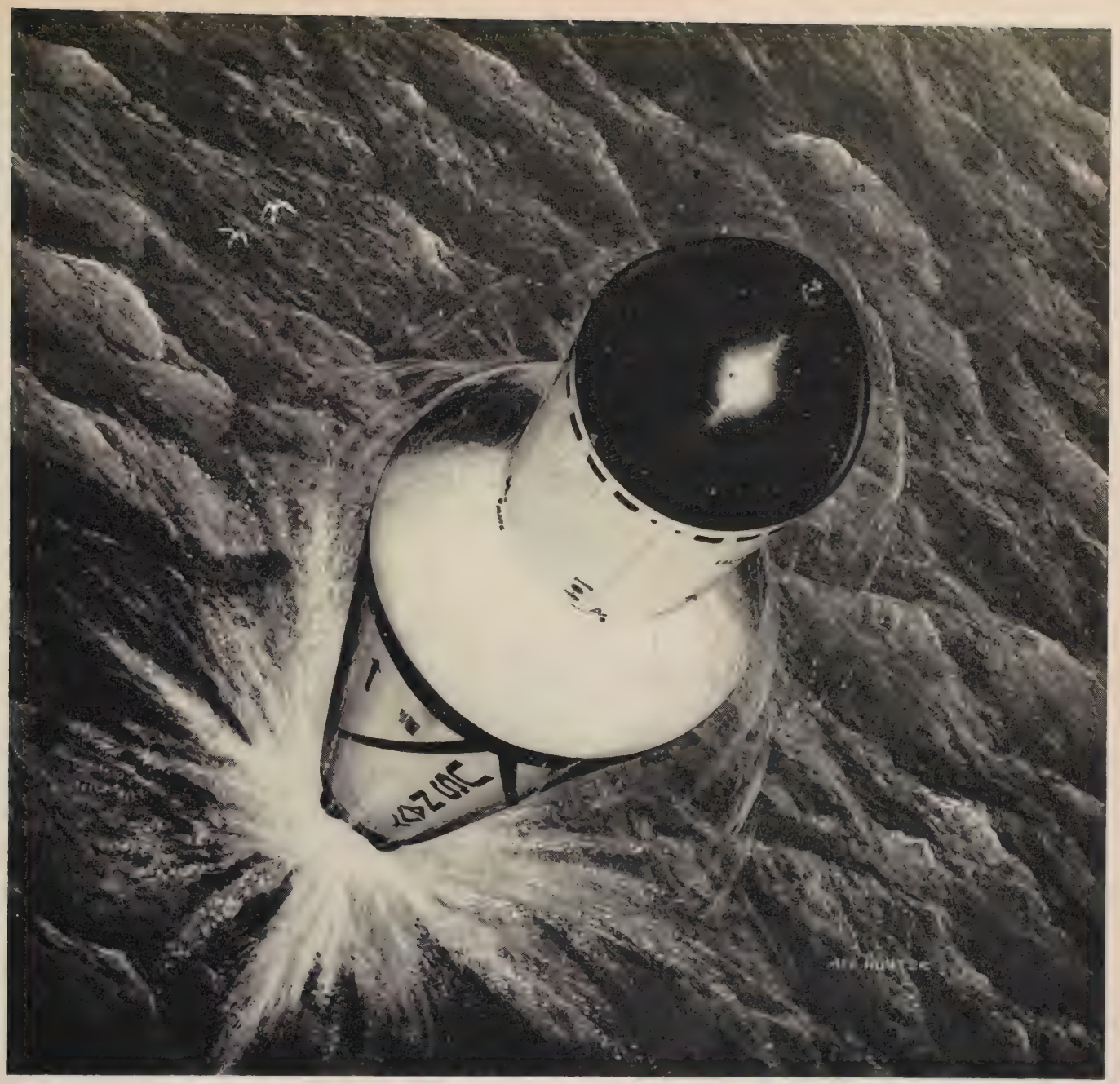

Project: **SALT WATER PUNCH**

Filter Application: **PROTECT HYDRAULIC CONTROLS**

Filter: **PUROLATOR**

The Polaris and the nuclear powered submarines which will carry and launch it form a mobile striking force that commands respect. Wherever they may be, it is imperative that, when the signal is given, the Polaris takes off and goes straight to the target.

Hydraulic control circuits play an important role in the programmed flight of the Polaris. To insure against malfunctions in the circuits, Purolator filters are designed as an integral part of many of them, to specifications set by Lockheed Missiles and Space Division, Polaris missile system manager.

Purolator engineers will gladly bring to your needs the filtration knowledge they provide for Polaris and other top-priority projects. A letter or phone call describing your aircraft or missile filtration requirements will receive prompt attention.

Filtration For Every Known Fluid

PUROLATOR

PRODUCTS, INC.

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Expanding the Frontiers of Space Technology in

AERO—DYNAMICS

■ Pioneering work at Lockheed is being conducted in free molecular flow in orbital flight; high altitude atmospheric properties; trajectory studies and missile flight dynamics; celestial mechanics with emphasis on orbital tracking predictions and de-orbiting.

An important aspect of Lockheed's basic research and development is the systems approach to optimum flight performance by means of computer simulation of missile airframe, autopilot and guidance characteristics. Other studies are being made in the problems of lunar and planetary probes and man-in-space.

ENGINEERS AND SCIENTISTS

Lockheed Missiles and Space Division programs reach far into the future and deal with unknown environments. Exciting opportunities exist for engineers and scientists to contribute to the solution of new problems in these fields. If you are experienced in one or more of the above areas or have background in related work in aerodynamics or celestial mechanics, we invite your inquiry. Write: Research and Development Staff, Dept. I-2-16, 962 W. El Camino Real, Sunnyvale, California. U.S. citizenship required.

Lockheed

MISSILES AND SPACE DIVISION

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BEARINGS need no maintenance

Production of a new line of self-lubricating Monoball self-aligning plain bearings is announced by **Southwest Products Co., Dept. S/A, 1705 S. Mountain Ave., Monrovia, Calif.** Called Dyflon, they require no maintenance or service and are recommended for applications requiring low coefficiency of friction, long service life without lubrication and high dynamic load-carrying capacity, it is said.

These bearings are available in a wide vaviety of both plain types and rod end types in bore sizes from ¾ to six inches diameter. Rod end types are offered with either externally or internally threaded shanks.

Write in No. 360 on Reader Service Card

THERMAL-HEATER is lightweight

This new Thermal-Heater is a 43-W circular heater weighing less than ¼ oz (including 12 in leads). Less than 0.030 in. thick over the element and less than 0.065 in. thick over the leads. It may be clamped or cemented in place, says **Minco Products, Inc., Dept. S/A, 740 Washington Ave., North, Minneapolis 1, Minn.**

Flexible construction permits application to flat or curved surfaces. Insulation resistance is 1,000 V rms. Heaters are fabricated to customers' specifications.

Write in No. 361 on Reader Service Card

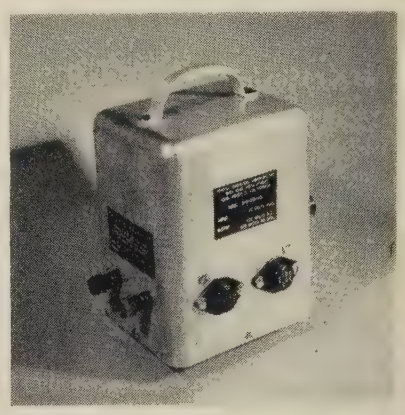
CIRCUIT BREAKER for high voltage

This Klixon D6760-5 thermal type, three-phase circuit breaker is a new model for use where high voltage power is needed. The –5 version of the basic design has greater electrical clearances between phases. This eliminates the possibility of arcing between phases on short circuit interruption, says **Metals & Controls Corp., Dept. S/A, Attleboro, Mass.**

The new unit is suitable for use on 220/440 Vac systems operating at 60 or 400 cps. Electrical ratings are five to 60 amperes. It will handle short circuit between 800 and 1000 amperes at 440 V. The unit weighs about eight ounces. It has simultaneous tripping of all three phases with an overload in any one or more phases. The breaker trips from two to six milliseconds on short circuit interruption. It meets MIL-C-5809.

Write in No. 362 on Reader Service Card

STATIC INVERTERS give high reliability



This S.I.C. model 12-115-60 AC series static inverters feature an exclusive non-saturating time-constant design affording frequency stability over as much as 60% of the input dc voltage. Superior reliability and efficiency up to 95% is obtained by elimination of Zener diodes and other voltage regulating devices. Standard units have square-wave output; sinusoidal output configurations are also available, says **Static Inverters Corp., Dept. S/A, 2501 E. 68 St., Long Beach, Calif.**

Developed for applications where the primary power source is dc, the inverters will handle a wide variety of power factors.

Write in No. 363 on Reader Service Card

MOTOR-GENERATOR is new size

The availability of Size 8 Motor-Generators is announced by **G-M Laboratories Inc., Dept. S/A, 4300 North Knox Ave., Chicago 41, Ill.** It has an outer diameter of 0.750. The tachometer-generator portion of the unit can be furnished for operation either 18 or 26 V, 400 cycles. It has a gradient of 0.250 V per M RPM and a maximum null voltage of 0.010 volts RMS.

The motor portion can be furnished with any combination of voltages up to 40 V on both the fixed and control phases, all 400 cycle. Stall torque is 0.3 oz in., with a no-load speed of 6200 rpm.

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more on page 280

DELCO RADIO

NEW POWER TRANSISTORS

MILITARY–COMMERCIAL

	2N1168	2N392	2N1011	2N1159	2N1160
V_{cb} max.	50	60	80	80	80 volts
I_c max.	5	5	5	5	7 amp.
I_{co} (V_{ec} 2 volts) Typical 25 °C.	65	65	65	65	65 μ a.
HFE (3 amp.)	–	60-150	30-75	30-75	–
HFE (5 amp.)	–	–	–	–	20-50
AC Power Gain (I_c = 0.6 amp.)	37 DB	–	–	–	–
V_{ceo} (I_c = 1 amp.)	40 typical	50 typical	60 min.	60 min.	60 volts min.
Thermal Gradient max.	1.5	1.5	1.2	1.2	1.2° c/w

Delco Radio rounds out its power transistor line with this new 5-ampere germanium PNP series. Types 2N1168 and 2N392 are specially designed for low-distortion linear applications, while 2N1159 and 2N1160 are outstanding in reliable switching mode operations.

Type 2N1011 is designed to meet MIL-T-19500/67 (Sig. C). It joins 2N665, MIL-T-19500/68 (Sig. C); 2N297A, MIL-T-19500/36 (Sig. C) and JAN2N174, MIL-T-19500/-13A to provide a selection for military uses.

Write today for engineering data on Delco Radio's line of High Power Transistors.

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FENN

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DIRECTIONAL COUPLERS have high directivity

All units in its complete line of dual high-directivity directional couplers exhibit the same flat coupling response (±0.4) and high directivity (40 db min) as its single high-directivity coupler units, says **Narda Microwave Corp., Dept. S/A, 118-160 Herricks Rd., Mineola, N.Y.**

All models, with the exception of the M-band, are constructed from precision waveguides; milled blocks of tellurium copper are used in the units covering 50 to 75 kmc. Input and output arms of all models are terminated with standard cover flanges. Coupling value of all units is 20 db; primary line VSWR is 1.05 max (1.10 for M-band); secondary line VSWR is 1.15 max.

Write in No. 365 on Reader Service Card

DELAY LINE has low insertion loss

This ultrasonic delay line has extremely low secondary levels and insertion loss as well as wide band width. The unit, with a delay of 900 microseconds, has an average maximum secondary level of over 70 db below the main delay, triple travel signals of 60 db, and direct feed through over 80 db over a 10-mc band, centered at 40 mc, says **Arenberg Ultrasonic Lab., Inc., Dept. S/A, 94 Green St., Jamaica Plain 30, Mass.**

The band width to the 3-db points is 22 mc. Insertion loss into 50 ohms is 55 db with a capacity of 60 micro-microfarads at input and output. The unit is 14½ in. in diameter and 1 in. high and weighs less than 7 lb in an evacuated aluminum case which will meet extreme military environmental test conditions.

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AXIAL BLOWER is reduced in size

This tube axial fan, Model S2223-3, using 1 in. diameter motor, delivers 40 cfm at 16500 rpm at 0 in S.P. It operates from a 200 V, 3 ø, 400 cycle source, says **Air-Marine Motors, Inc., Dept. S/A, 369 Bayview Avenue, Amityville, N.Y.** Because of its unique construction, the blower can withstand ambient temperatures of up to 125 deg. C with a minimum life of 2000 hr.

This unit meets all the requirements of Mil-E-5272. It has passed shock, vibration, salt spray, humidity, and fungus tests. After each phase of environmental testing, the unit is checked and subjected to a 1500 V hi-pot test for one minute. Overall dimensions are 2 in. by 2¼ in. by 2¼ in.

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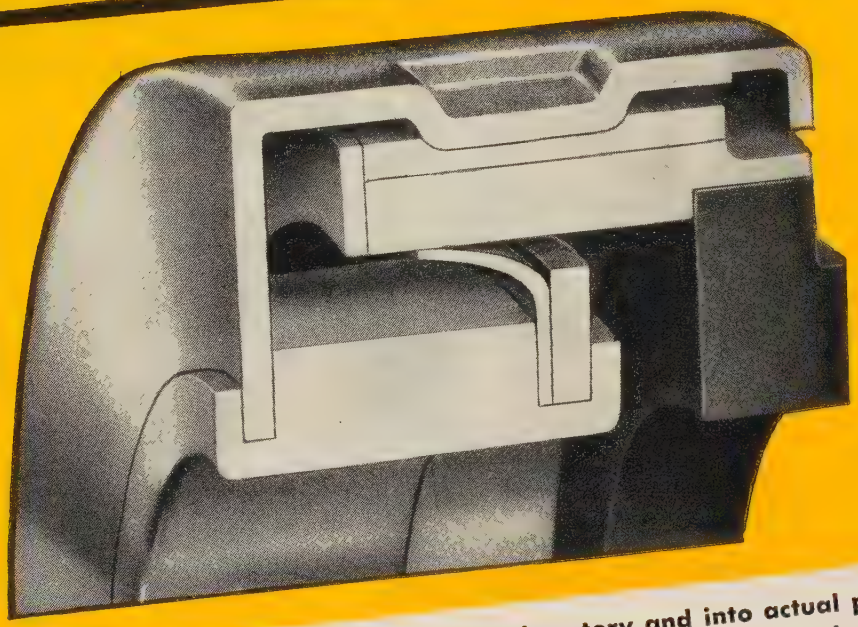
NEW Only Gits Met-L-Seal* Seals at -65° to +850° F.



Now beyond the Research-Development Laboratory and into actual production — nothing like it on the market! Consider these exclusive design advantages, producing a built-in "missile reliability":

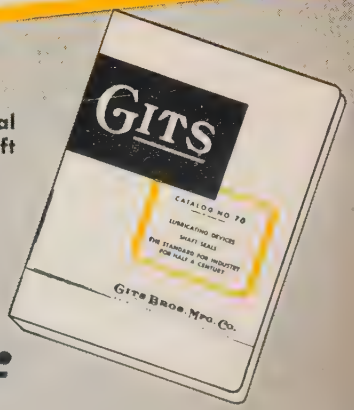
1 Hydraulic balance producing optimum sealing under both static and dynamic conditions — not always available in other all-metal seal designs.

2 Functions at temperatures, pressures and speeds in excess of capabilities of currently used organic materials — in minimum space required by aircraft-missile applications.

3 No internal fatigue. All components, except seal face, are made of various high-temperature alloy steels, each with the optimum combination of properties necessary to its function. (Exclusive Gits design makes Met-L-Seal operable at temperatures even higher than 850°, limited only by metallurgical progress in high-temperature alloy steels.) Positive guarantee against sudden complete operational failure and other drawbacks of synthetic-elastomer seals in extreme operating conditions.

4 No "shelf life" problems. No "cure-date" limitations as are necessary with synthetic-elastomer seals.

Send for new "Advance Catalog" or submit your seal problem to the experienced engineers of the Gits Aircraft and Missile Seal Division.



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G-E KSR* TANTALYTIC* CAPACITORS

for computer, missile, radar, and airborne electronic equipment.

- Provide high microfarad ratings in cases of nominal size and weight without loss of quality or reliability.
- Offer voltage ratings to 150 volts d-c from −55C to +85C; to 100 volts for 125C operation.
- Are up to 50% lighter, 30% smaller compared with lower microfarad units rated for 125C.

SPECIFYING INFORMATION on G.E.'s complete Tantalytic line is available from your nearest Apparatus Sales Office, or write for GEA-6766A, to General Electric, Section 449-11, Schenectady 5, N. Y.

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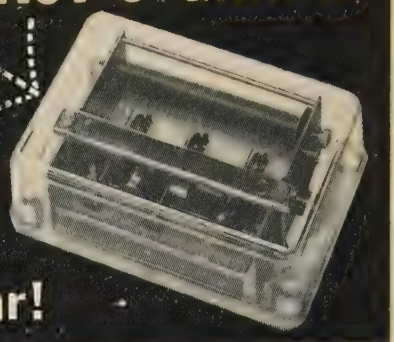

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Savings like this are being made all the time by companies who use Impact-O-Graphs to determine the amount of shock products can withstand without damage and plan their shipping and packaging procedures accordingly. Many suppliers to aircraft and missile manufacturers use Impact-O-Graphs to assure shipping reliability.

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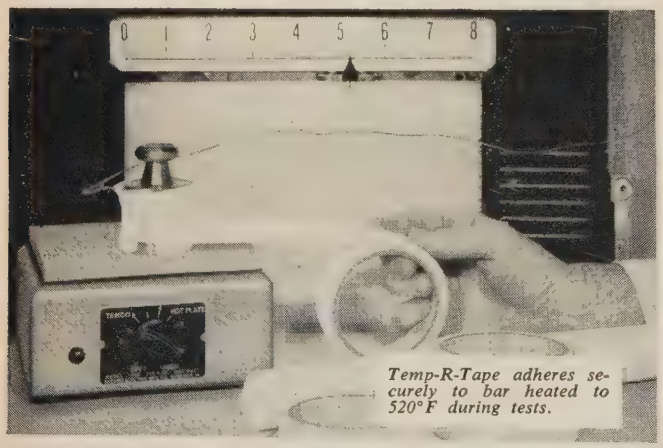

Temp-R-Tape adheres securely to bar heated to 520°F during tests.

CHR PRESSURE-SENSITIVE TEFLON® TAPES

- *−100°F to 500°F applications*
- *Class H and Class C insulation*
- *Non-stick and low friction facing*
- *Chemical resistant facing*
- *Easy to apply*

Temp-R-Tape is available from stock in rolls and sheets. All four types — Temp-R-Tape T; TH; C and TGV — combine some form of Tefion backing with silicone polymer adhesive to provide easy-to-apply pressure-sensitive and thermal curing pressure-sensitive tapes for electrical and mechanical applications. Designed for extreme temperatures, Temp-R-Tapes possess high dielectric strength, low power factor, high elongation, negligible moisture absorption, are non-corrosive and non-contaminating.

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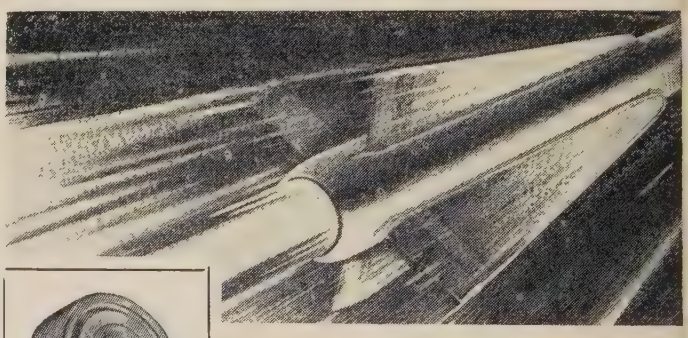

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B.M.B. Miniature Bearings to the highest precision limits, are made specially for Space craft, missile or ground support instrumentation.

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There are associate contractors—and then there are associate contractors.

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KNOWMANSHIP is our word for describing Eclipse-Pioneer's unique qualifications in these areas. KNOWMANSHIP stands for the critical combination of technical knowledge, experienced management and specialized craftsmanship that we offer prime contractors.

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Backing up this proved experience and management ability are the physical resources needed "to get the job done". These include over 9,500 skilled people and more than 1.1 million square feet of plant area.

In short, we offer you *professional partner* KNOWMANSHIP in advanced aircraft and missile sub-system development and production. Our representatives are at your call wherever and whenever you have a project to discuss.

69% of E-P's procurement dollars go to small business.

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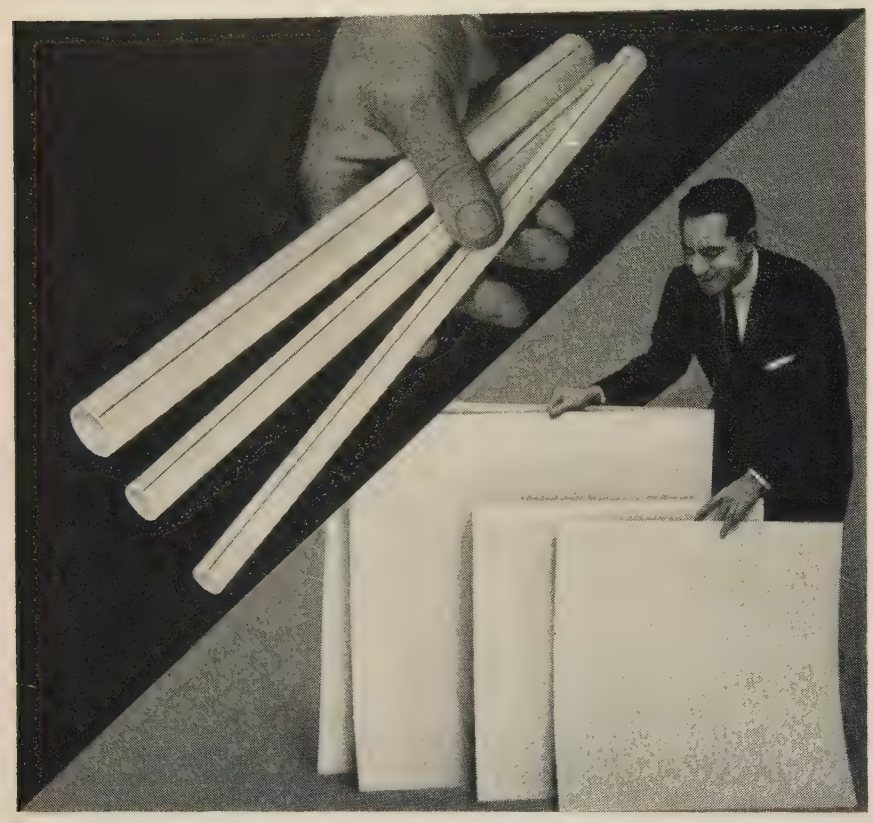
TEFLON* NEWS FROM R/M

Now, larger sheets . . . color-striped thin-wall tubing



Easy identification in multiple tubing installations is made possible by R/M color-striped thin-wall "Teflon" tubing. Tubing is also available without striping.

Larger sheets. R/M now makes 1/32-in.-thick Teflon in 36 x 36 in. sheets. Other "Teflon" products include tape, tubes, rods, hose and bondable "Teflon."

Here are two big features added to Raybestos-Manhattan's extensive line of "Teflon" products for use in aircraft, missile and rocket components. First, 1/32-in.-thick "Teflon" can now be supplied in 36 x 36 in. sheets . . . other thicknesses available in sheets up to 48 x 48 in. And second, to permit the ready identification of lines in multiple installations—R/M thin-wall "Teflon" tubing is now available with a permanent identifying stripe in a range of colors.

These additions reflect R/M's continuing program to extend applications for "Teflon." This program — begun soon after the introduction of "Teflon"—has provided R/M engineers with a vast fund of know-how . . . where to apply "Teflon," how to design with it, and how to fabricate it. Let R/M's "Teflon" know-how work for you. Contact your nearest R/M district office for friendly, competent assistance. Or write for literature to Plastic Products Division, Manheim, Pa.

*A Du Pont trademark

R/M

RAYBESTOS-MANHATTAN, INC.

PLASTIC PRODUCTS DIVISION FACTORIES: MANHEIM, PA.; PARAMOUNT, CALIF.

Contact your nearest R/M district office listed below for more information or write to Plastic Products Division, Raybestos-Manhattan, Inc., Manheim, Pa.

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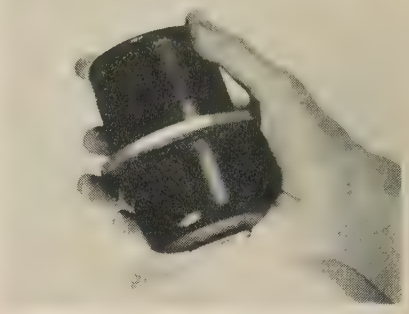
LOS ANGELES 58 • MINNEAPOLIS 16 • NEW ORLEANS 17 • PASSAIC • PHILADELPHIA 3
PITTSBURGH 22 • SAN FRANCISCO 5 • SEATTLE 4 • PETERBOROUGH, ONTARIO, CANADA

RAYBESTOS-MANHATTAN, INC., Engineered Plastics • Asbestos Textiles • Mechanical Packings • Industrial Rubber Sintered Metal Products • Rubber Covered Equipment • Abrasive and Diamond Wheels • Brake Linings Brake Blocks • Clutch Facings • Laundry Pads and Covers • Industrial Adhesives • Bowling Balls

Write in No. 216 on Reader Service Card at start of Product Preview Section

FREE GYRO takes severe vibration

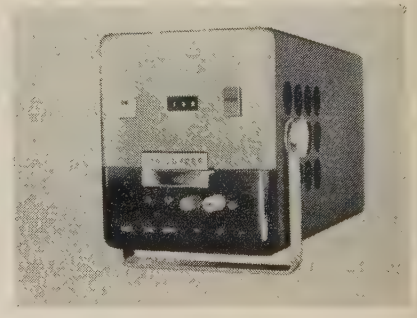


This miniature free gyroscope, weighing 3½ lb and able to withstand vibration of ten to 1000 cps at ten g and 1000 to 2000 cps at 20 g with two-minute sweep cycles without the benefit of vibration isolators, is now in production at **Iron Fireman Manufacturing Co., Dept. S/A, 2838 S.E. Ninth Avenue, Portland 2, Oregon.**

Designated Model N4100, it is a cageable, two-axis, free gyro designed especially for missile application. Angular displacements are indicated by a synchro pick-off on the outer gimbal. Construction throughout is of heat treated cast stainless steel and a center-of-gravity flange is provided for mounting.

Write in No. 370 on Reader Service Card

DIGITAL VOLTMETERS have printout



The Series A Digicorder, available in twenty different models, measures millivolts accurately with both a digital visual indication and direct electrical readout. A sensitivity of better than 2.5 microvolts is provided in the basic model and an accuracy of 1 part in 1000 is retained in all models, says **Computer Equipment Corp. ,Dept. S/A, 1931 Pontius Ave., Los Angeles 25, Calif.**

The Digicorder measures 6 in. W by 6½ in. H by 14½ in. D. Full-scale ranges of zero to 10 mv, 100 mv, 1 V, 10 V, and 100 V are available without use of external amplifiers. Visual reading are displayed continuously, and remote electrical printout can be commanded by means of a push button on the face of the instrument.

Write in No. 371 on Reader Service Card

more on page 286

from MOOG:

advanced . . .

Thrust Vector Control Systems

Consult Moog for assistance in solving hydraulic system problems

Moog's integrated hydraulic servosystems are lightweight and compact packages which include auxiliary power units and electrohydraulic servoactuators. The unit above was designed to position ICBM rocket engine nozzles for thrust vector control. A unique mechanical feedback arrangement within the servoactuator eliminates the need for electronic feedback elements. Moog's integral system design provides complete servocontrol packages for reliable, high performance operation.

MOOG SERVOCONTROLS, INC. PRONER AIRPORT, EAST AURORA, NEW YORK

LEADING INNOVATOR AND PRODUCER OF ELECTROHYDRAULIC SERVOVALVES

Write in No. 217 on Reader Service Card at start of Product Preview Section

How KENNAMETAL* Sealing Rings...

Help to Withstand High Temperatures . . . A jet engine shaft seal of Kentanium,* a titanium carbide, operating without lubrication at 15,000 surface feet per minute at 1000°F and 0.6 pounds pressure per lineal inch of circumference outperformed every other material tried. Kentanium is stress-free, dimensionally stable, maintains great strength and provides exceptional resistance to abrasion. It is providing all of these advantages on many applications . . . at temperatures up to 2000°F and as high as 5000°F for momentary service.

Help Solvent Separators to Resist Abrasion . . . On this job, Kennametal rings of Grade K96 were installed, replacing conventional seals which had at no time given more than two months' service and had sometimes failed in only 30 hours. Kennametal rings were inspected after six months in service, showed no perceptible wear and were returned to service. The customer predicts an ultimate service advantage of 50 to 1.

Help to Power Rockets . . . Here the sealing rings are used to handle red fuming nitric acid. After extensive testing of materials, rings made of Kennametal K501, a platinum-base composition, were chosen. The manufacturer reports: "Kennametal ring sealing results have been far superior to any other material with no indication of seal face wear." This was after the best life of the rings previously used had been exceeded.

For details, write for 24-page Booklet B-111, "Characteristics of Kennametal" . . . and 12-page Booklet B-444 which describes "Kentanium." KENNAMETAL INC., Dept. SP, Latrobe, Pa.

*Trademark

3172

INDUSTRY AND KENNAMETAL ...Partners in Progress

Write in No. 248 on Reader Service Card

BUTTERFLY VALVE gives positive sealing

This line of cryogenic butterfly valves provides positive sealing over a temperature range of −320 to +165 deg F, and a pressure range of four psi to 200 psi, says **B. H. Hadley, Inc., Dept. S/A, 1427 South Garey Avenue, Pomona, Calif.**

Other special features of the valves include rapid opening and closing time, minimum leakage, high flow capacity, low pressure drop, liquid or gaseous fluid service, and minimum installation envelope. Missileborne units have been qualified in sizes of four, six, seven, nine and 11 in. inside diameter, and test stand valves to 12 in. in diameter.

Write in No. 372 on Reader Service Card

AIRCRAFT INSTRUMENTS in new line

This line of aircraft electric-quantity instruments with integral lighting capability, indicating generator load, voltage, frequency, and power consumption, is for use on high-speed commercial and military aircraft. Both ac and dc types are available, says, **General Electric, Dept. S/A, Schenectady 5, N.Y.**

The ac ammeters, voltmeters, and the watt-meter portion of the watt-varometers are accurate to + 2 per cent. Frequency meter accuracy is ¼ per cent of normal frequency at 400 cycles and ½ per cent over the entire range of 380-420 cyp. All instruments having dc elements are self-shielded to reduce compass interference and all come in a standard two inch case size with a 1-⅞ in. dial.

Write in No. 373 on Reader Service Card

DATA SYSTEM simplifies flight displays

Flight data previously requiring ten indicators have been integrated into four displays in this flight data system, says **Kelvin Hughes (Aviation), Ltd., Dept. S/A, Winchester Rd., Basingstoke, Hampshire, England.** Displays are incorporated for speed, height, attitude and navigation information.

The display units, which are servo-operated, receive data from separate sensing, detector and computer units. Components include an aerodynamic computer, which accepts information from pitot, static and temperature sensors and computes indicated air speed and Mach number for the speed display. An attitude indicator accepts signals from a remote gyro reference and presents pitch and roll information in all attitudes of flight.

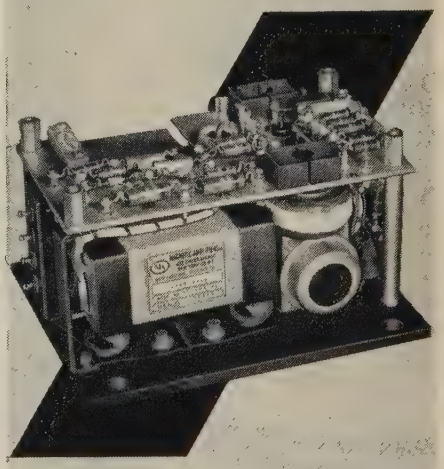
Write in No. 374 on Reader Service Card

New PRECISION FREQUENCY

STATIC INVERTER SUPPLY

INPUT 28V D.C. ± 10%
OUTPUT *Nom.* 115V ± 2%
400 CPS ± 0.01%
1 Ø (2- or 3-phase output available)
RATINGS: 30VA 50VA 100VA
Higher ratings available.

APPLICATION:
For gyro wheel supplies and where precise 400 cycle voltages are required in aircraft, radar and missile computers.



FEATURES:
PRECISION OUTPUT FREQUENCY
RUGGED
EXCELLENT WAVEFORM
SIMPLICITY OF CIRCUITRY
FAST STARTING TIME
GOOD VOLTAGE REGULATION
throughout an adjustable range
ISOLATED CASE DESIGN
HIGH RELIABILITY
VIBRATION ISOLATED
COMPACT
LIGHTWEIGHT
MILITARY SPECIFICATIONS
(Send for Bulletin S-864)

MA

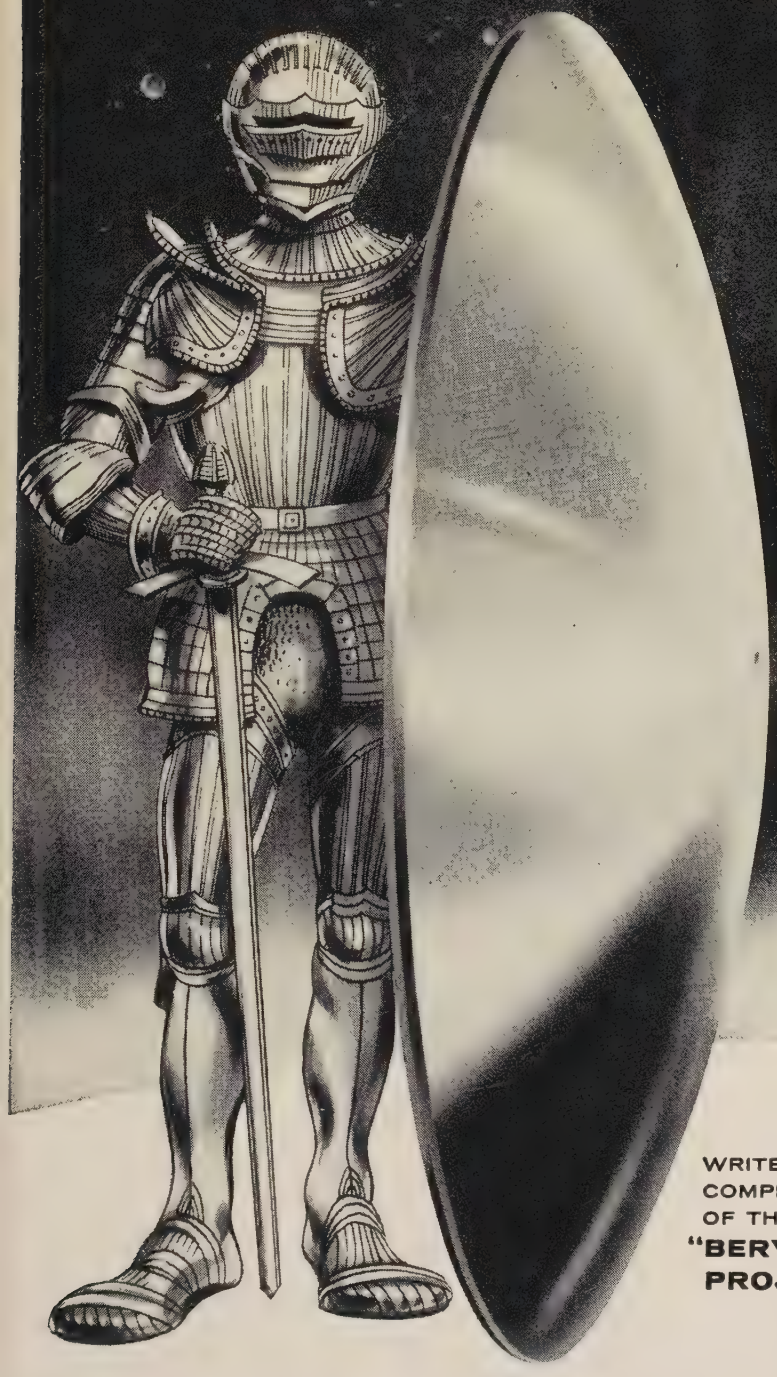
MAGNETIC AMPLIFIERS, INC.

632 TINTON AVENUE • NEW YORK 55, N.Y. • CYPRESS 2-6610

West Coast Division
136 WASHINGTON ST. • EL SEGUNDO, CAL. • OREGON 8-2665

Write in No. 218 on Reader Service Card

SHIELD FOR THE BATTLE OF SURVIVAL IN SPACE



QMV*
BERYLLIUM HEAT SINK

(SIX-FOOT DIAMETER FORGING PRODUCED FOR THE NASA SPACE-CAPSULE TESTING PROGRAM)

WRITE FOR YOUR COMPLIMENTARY COPY OF THE CASE HISTORY **"BERYLLIUM IN PROJECT MERCURY"**

*QMV is a Trade Mark of THE BRUSH BERYLLIUM COMPANY

BRUSH BERYLLIUM

4301 PERKINS AVENUE · CLEVELAND 3, OHIO

beryllium · beryllium oxide · beryllium alloys

Write in No. 219 on Reader Service Card at start of Product Preview Section

data preview

FACILITIES—A 16-page facilities report has been prepared to describe the fuel control equipment engineering and manufacturing capabilities of **Chandler Evans Corp., Dept. S/A, West Hartford 1, Conn.** Fuel system components produced for turbojet engines and jet aircraft include servomechanisms, control valves, actuators, pumps, and pressure regulators.

Write in No. 375 on Reader Service Card

VALVES—A six-page folder describing valves made to handle gas pressures to 15,000 psi and liquids down to —400 deg F has been made available by **Specialty Engineering Co., Dept. S/A, 264 W. Fairview, San Gabriel, Calif.** The Aero Valves bulletin considers shuttle, check and safety relief valves.

Write in No. 376 on Reader Service Card

EXPLOSIVE ORDNANCE—A technical data file on explosive ordnance for missile, rocket, aircraft and ground support systems has been compiled by **McCormick Selph Associates, Dept. S/A, Hollister Airport, Hollister, Calif.** The devices described include primers, squibs, igniters, explosive bolts, ejectors, and others.

Write in No. 377 on Reader Service Card

VIBRATION MOUNTS—Catalog 3 is a folder describing a line of all-metal vibration mounts and bases made by **K. W. Johnson & Co., Inc., Dept. S/A, 1825 Webster St., Dayton 4, O.** Models include high-frequency mounts, suspension mounts, and stabilizer types for high speed jets, missiles, and other applications.

Write in No. 378 on Reader Service Card

TEST CONSOLE—Details of the Model 9500 hydraulic components test console for the missile industry have been presented in Bulletin 1382 by **George L. Nankervis Co., Dept. S/A, 15499 Fullerton, Detroit 27, Mich.** The 2-page bulletin includes information on hydraulic circuitry, specifications, instrumentation lists, and construction of the 5000-psi console.

Write in No. 379 on Reader Service Card

FLEXIBLE TUBING—Data sheets on several types of flexible tubing for electrical applications have been issued by **L. Frank Markel & Sons, Dept. S/A, Norristown, Pa.** Tubing in the Flexite line is made of Teflon or other resins and includes Flexite E, a type suited to airborne application because of its unusual resistance to brittleness at low temperatures.

Write in No. 380 on Reader Service Card

CAPABILITIES—This facilities report, in brochure form, points out that over 220 different hydraulic, pneumatic, electronic and mechanical components for conveying power are made by **Sargent Engineering Corp., Dept. S/A, 2533 E. 56th St., Huntington Park, Calif.** The brochure illustrates equipment, techniques, and typical products, the last including many made for the aircraft and missile industry.

Write in No. 381 on Reader Service Card

FORGINGS—Typical products made by the closed die forging technique for the aircraft and other fields have been described in the 22-page Brochure SB-1258, available from **The Park Drop Forge Co., Dept. S/A, E. 79th St. and Buck Ave., Cleveland 3, O.** Forgings include landing gear parts, turboprop discs, brake assembly components, cams, and master and articulated rods, among others.

Write in No. 382 on Reader Service Card

ENGINEERING—Details of an engineering service for design and development work in a wide variety of industrial fields are included in a facilities report issued by **Visioneering Co., Dept. S/A, 11830 Brookpark Rd., Cleveland 30, O.** Clutch test stands, dynamometer test stands, undercarriages for missile-carrying trailers, and very large weldments are but a few of the units engineered and built by the company.

Write in No. 383 on Reader Service Card

ALUMINUM—"Designing with Aluminum," a collecton of a series of technical information sheets on characteristics, capabilities and use of aluminum in a wide variety of industrial applications, is available from **Kaiser Aluminum & Chemical Sales, Inc., Dept. S/A, 919 N. Michigan Ave., Chicago 11, Ill.** The 24 topics covered in the booklet present facts on corrosion resistance, strength after working, soldering, die casting, and thermal conductivity.

Write in No. 384 on Reader Service Card

SYNCHROS—The electrical parameters of synchros and resolvers are defined in detail in a chart, suitable for wall-mounting, which has been revised in accordance with military specifications and SAE ARP-461 by **Theta Instrument Corp., Dept. S/A, 48 Pine St., East Paterson, N.J.** This most recent issue of the Synchro Data Chart also tabulates the various connections for null measurement.

Write in No. 385 on Reader Service Card

ROTO-DRIVE ACTUATORS—Literature is available from **Parameters, Inc., Dept. S/A, New Hyde Park, New York,** on the features and applications of the roto-drive servo actuator, its environmental and functional testing services and equipment, and a unit measuring system made by Parameters.

Write in No. 386 on Reader Service Card

OVERHEAT PROTESTORS—**Metals & Controls Corp., Dept. S/A, Attleboro, Mass.,** has available two technical bulletins, MOPR-2 and MOPR-11, containing data on inherent overheat protectors for single-phase ac and dc, and for three-phase aircraft electric motors respectively. The literature gives construction, operation, electrical ratings, capacities, and weights of both open and hermetically sealed types.

Write in No. 387 on Reader Service Card

FLEXIBLE HOSE CONNECTORS—Over 2,000 standard models of flexible metal hose connectors are illustrated, described and individually priced in a catalog published by **Cobra Metal Hose, Dept. S/A, 5059 S. Kedzie Ave., Chicago 32, Ill.** Specifications and installation information are included.

Write in No. 388 on Reader Service Card

ALTERNATORS & INVERTERS—A four-page, four-color, illustrated bulletin on its permanent magnet alternators and rotary inverters is available from **Borg-Warner Corp., Dept. S/A, 3310 Vancouver St., Burbank, Calif.** Features and specifications are given and its facilities and services are briefly discussed

Write in No. 389 on Reader Service Card

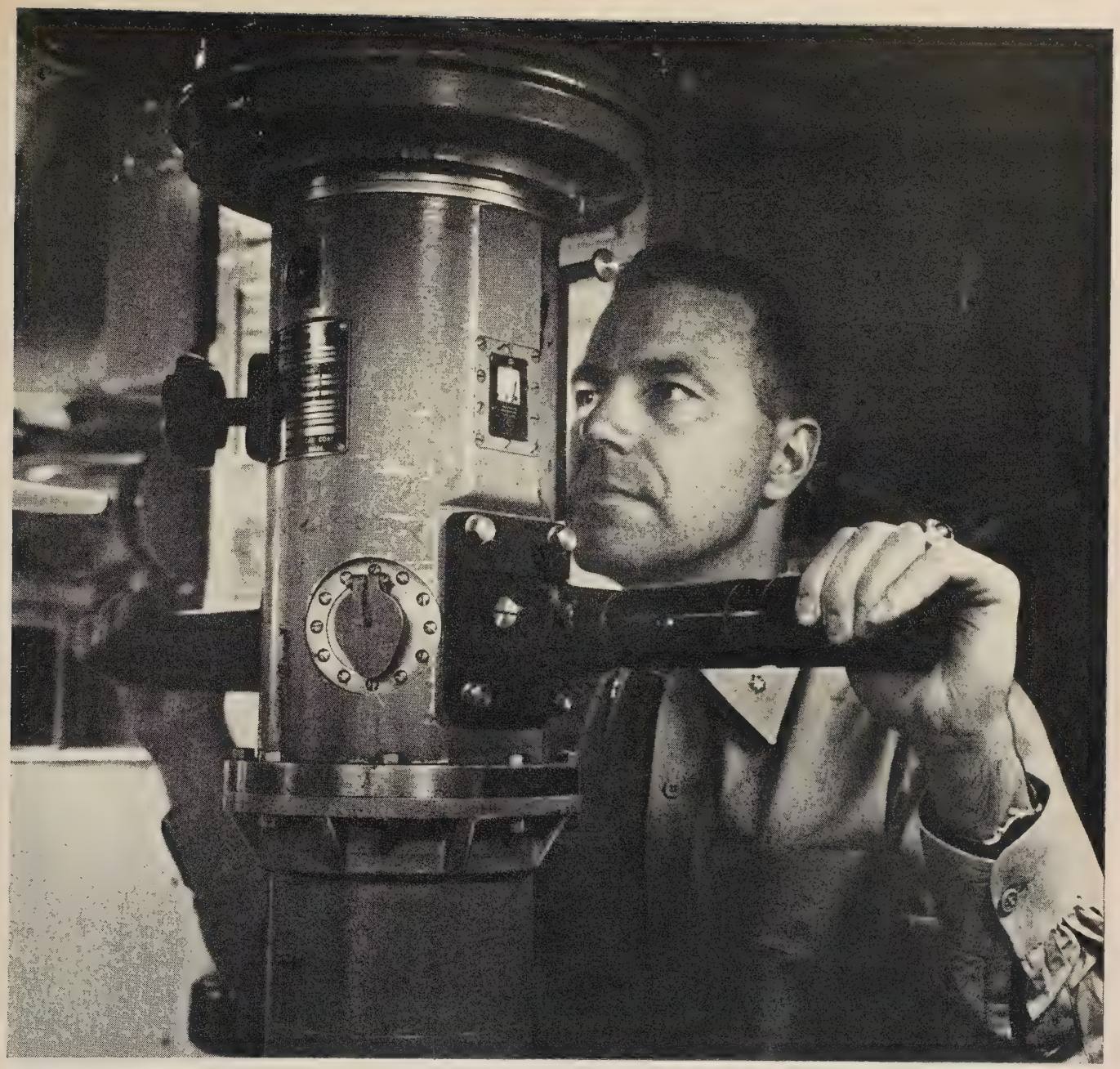
TRANSDUCERS—Catalog, No. 115811, describes **Rosemount Engineering Co.'s, Dept. S/A, 4900 W. 78th St., Minneapolis 24, Minn.,** line of temperature transducers and deiced pitot-static tubes and precision pressure transducers.

Write in No. 390 on Reader Service Card

GAS DAMPING—**Statham Instruments, Inc., Dept. S/A, 12401 W. Olympic Blvd., Los Angeles 64, Calif.** has issued a scientific research paper, Instrument Notes No. 33, outlining the concept of using gas as the damping medium for dynamic measuring devices. The new paper gives mathematic and graphic data permitting the designs of a wide variety of devices using the new gas-damping principle.

Write in No. 391 on Reader Service Card

more on page 292



COUNTDOWN...at full fathom five

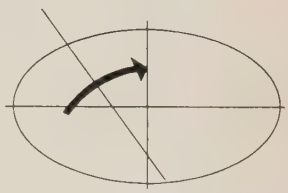
One day, a new fleet weapon system will be *on-station* beneath the ocean surface—ready to hurl retaliatory missiles toward strategic inland targets with pinpoint accuracy. This new weapon system will be part of the Navy's Polaris Fleet Ballistic Missile Program.

Though new in concept, the Polaris program makes full use of the precision Shipboard Inertial Navigation Systems (SINS) developed and produced by Autonetics for the United States Navy.

System design and components of earlier autonavigators have proved reliable in an Air Force supersonic missile, aboard the Navy's surface ship *USS Compass Island*, and on the *USS Nautilus* and *Skate*.

Advanced Autonetics' Shipboard Inertial Navigation Systems—like those to be used by the *USS George Washington*, the first Polaris-carrying submarine—will provide the critical missile alignment data to insure effective missile launching. SINS emits no tell-tale signals ... requires no receipt of external transmission at any time.

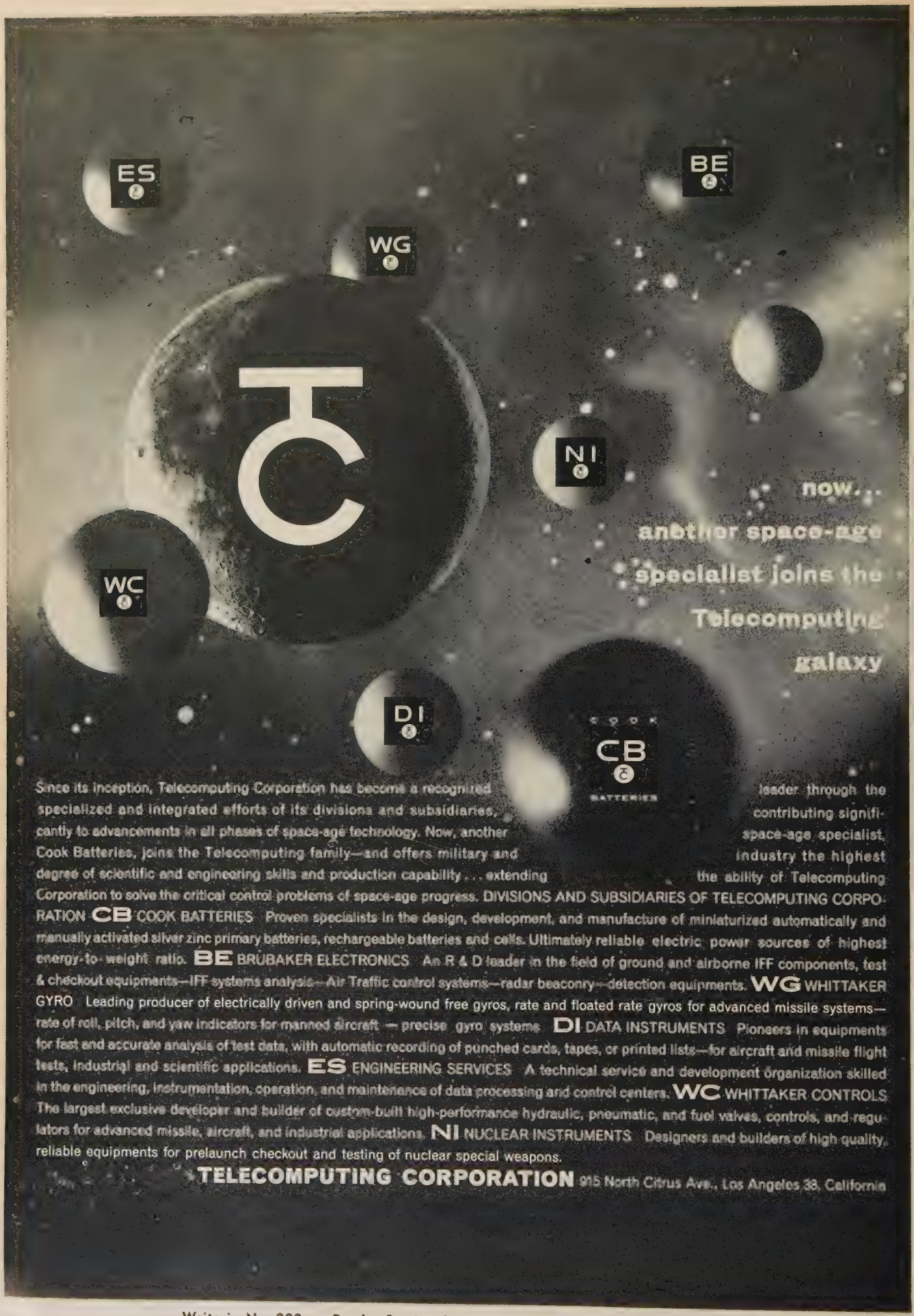
DID YOU KNOW?



The flattening of the earth at the poles can result in a navigational error of almost eleven nautical miles if not taken into account.

Inertial navigation by Autonetics

A DIVISION OF NORTH AMERICAN AVIATION, INC., DOWNEY, CALIFORNIA • REGIONAL OFFICES: WASHINGTON, D.C. AND DAYTON, OHIO
INERTIAL NAVIGATION/ARMAMENT CONTROL/FLIGHT CONTROL/COMPUTERS AND DATA PROCESSING

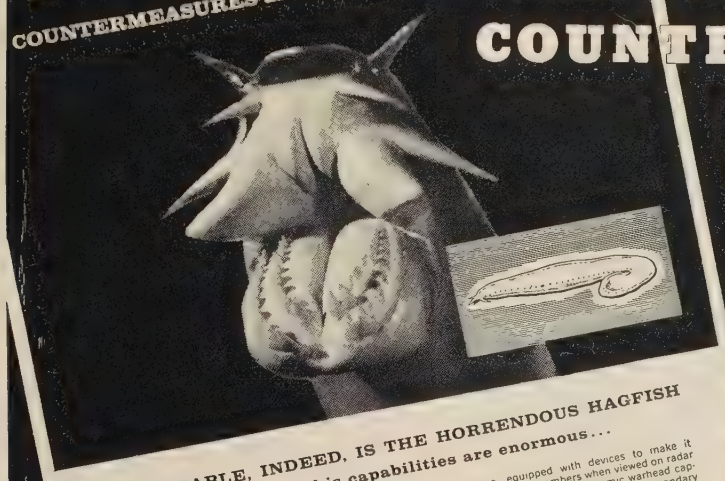


Since its inception, Telecomputing Corporation has become a recognized leader through the specialized and integrated efforts of its divisions and subsidiaries, contributing significantly to advancements in all phases of space-age technology. Now, another space-age specialist, Cook Batteries, joins the Telecomputing family—and offers military and industry the highest degree of scientific and engineering skills and production capability . . . extending the ability of Telecomputing Corporation to solve the critical control problems of space-age progress. DIVISIONS AND SUBSIDIARIES OF TELECOMPUTING CORPORATION **CB** COOK BATTERIES Proven specialists in the design, development, and manufacture of miniaturized automatically and manually activated silver zinc primary batteries, rechargeable batteries and cells. Ultimately reliable electric power sources of highest energy-to-weight ratio. **BE** BRUBAKER ELECTRONICS An R & D leader in the field of ground and airborne IFF components, test & checkout equipments—IFF systems analysis—Air Traffic control systems—radar beaconry—detection equipments. **WG** WHITTAKER GYRO Leading producer of electrically driven and spring-wound free gyros, rate and floated rate gyros for advanced missile systems—rate of roll, pitch, and yaw indicators for manned aircraft — precise gyro systems. **DI** DATA INSTRUMENTS Pioneers in equipments for fast and accurate analysis of test data, with automatic recording of punched cards, tapes, or printed lists—for aircraft and missile flight tests, industrial and scientific applications. **ES** ENGINEERING SERVICES A technical service and development organization skilled in the engineering, instrumentation, operation, and maintenance of data processing and control centers. **WC** WHITTAKER CONTROLS The largest exclusive developer and builder of custom-built high-performance hydraulic, pneumatic, and fuel valves, controls, and regulators for advanced missile, aircraft, and industrial applications. **NI** NUCLEAR INSTRUMENTS Designers and builders of high quality, reliable equipments for prelaunch checkout and testing of nuclear special weapons.

TELECOMPUTING CORPORATION 915 North Citrus Ave., Los Angeles 38, California

Write in No. 222 on Reader Service Card at start of Product Preview Section

COUNTERMEASURES and the myxine glutinosa



COUNTERMEASURES and Instruments for Industry

The I.F.I. "Menagerie Series", familiar to most electrical engineers, graphically illustrates the contributions made by I.F.I. to this exacting field of countermeasure engineering upon which our very survival may well depend...

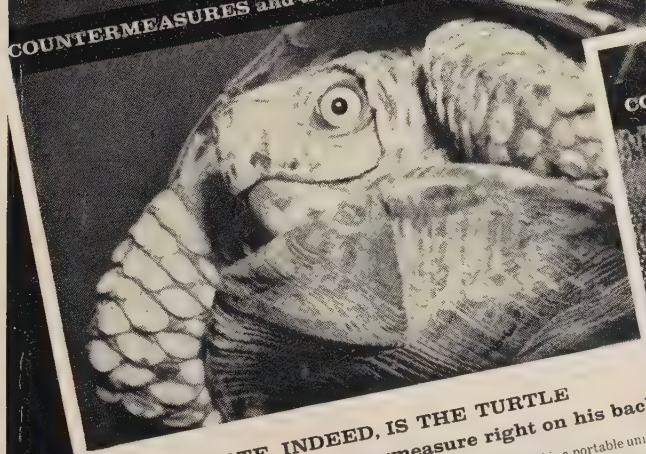
FORMIDABLE, INDEED, IS THE HORRENDOUS HAGFISH
though small in size, his capabilities are enormous...

Seventeen inches of devastating destruction are represented in the pictures above. Appearing to be no more than another small eel, this specimen can, in a matter of hours, eat his way through the skin of his victim and then proceed to devour everything except bone.

A small drone, equipped with devices to make it appear as one or more bombers when viewed on radar scopes, could very well carry an atomic warhead capable of delivering a devastating blow to a secondary target. Instruments For Industry has for many years

e Army,
perfec-
e fruits

COUNTERMEASURES and the testudinidea malaclemys



FORTUNATE, INDEED, IS THE TURTLE
for he carries his countermeasure right on his back

Man on the other hand must devise his own countermeasures if he intends to survive in this day of modern warfare. Instruments For Industry is actively engaged in this field working in close conjunction with the Army, Navy, Marines and Air Force.

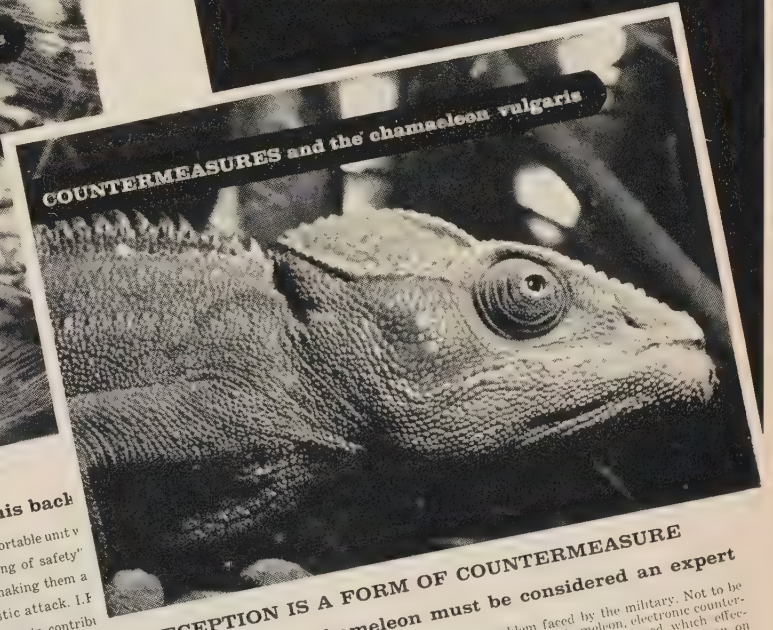
Recently developed is a portable unit v
in effect, places a "ceiling of safety"
personnel in the field making them a
invulnerable to ballistic attack. I.F
proud of this opportunity to contribu
the defense of our services.

An I.F.I. "ceiling of safety" protects these men against surprise ballistic attack.

INSTRUMENTS FOR INDUSTRY.
101 New South Road, Hicksville, L. I.

Graduate engineers with two or more years of circuit application in the fields of electronics or physics are invited to meet wi
John Hicks in an informal interview or send complete resume to: Dir. Personnel, IFI, 101 New South Road, Hicksville, New

COUNTERMEASURES and the chamaeleon vulgaris



DECEPTION IS A FORM OF COUNTERMEASURE
and at this the chameleon must be considered an expert

The approach to the problem of survival through countermeasures has been neatly solved by this handsome little fellow. By simply changing his color to match the surroundings the chameleon may take on the appearance of a brown twig, a green leaf or so completely blend into the immediate area that his enemy is hopelessly confused. This, in effect, is countermeasure in the truest sense. To confuse or mislead the enemy is often the problem faced by the military. Not to be outdone by the chameleon, electronic countermeasures have been developed which effectively confuse the presentations as seen on radar scopes. Defensive action is thereby delayed until too late. In this field, as well as many other forms of countermeasures, Instruments for Industry can apply exacting know-how and skill. The high degree of success achieved by IFI is proof of ability

Only one target is a true target. The big question... which one?

INSTRUMENTS FOR INDUSTRY, I
101 New South Road, Hicksville, L. I., N

Graduate engineers with two or more years of circuit application in the fields of electronics or physics are invited to meet w
John Hicks in an informal interview or send complete resume to: Dir. Personnel, IFI, 101 New South Road, Hicksville, New

Enlarged photos of the I.F.I. "menagerie" available on request to Dept. 201.

ifi

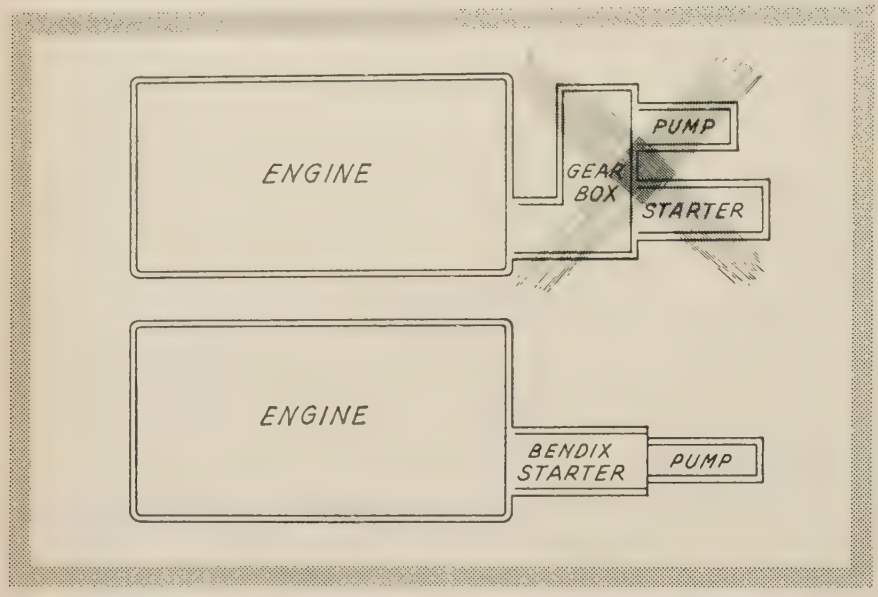
INSTRUMENTS FOR INDUSTRY, Inc.

101 NEW SOUTH ROAD HICKSVILLE, L. I., N. Y.

Graduate engineers with two or more years of circuit application in the fields of electronics or physics are invited to meet with Mr. John Hicks in an informal interview or send complete resume to: Dir. Personnel, I.F.I., 101 New South Road, Hicksville, New York.

Write in No. 223 on Reader Service Card at start of Product Preview Section

BENDIX EXCLUSIVE FOR JET STARTERS: AN EXTRA ENGINE PAD!



NO GEAR BOX *is needed with the Bendix Utica air turbine starter with accessory drive pad. Compare standard engine arrangement, above, with Bendix Utica mounting, below.*

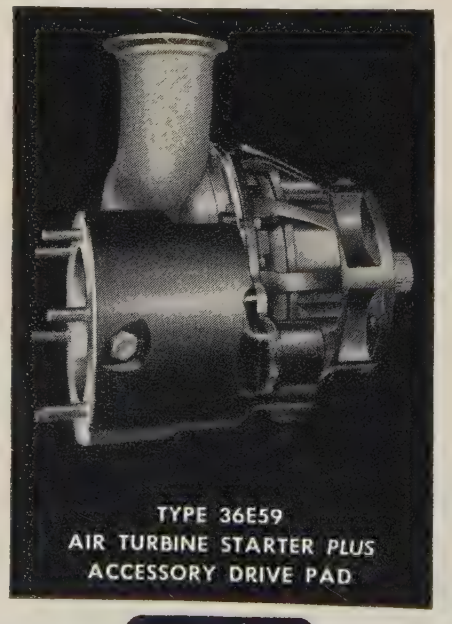
For the first time, Bendix Utica offers an air turbine starter and accessory drive unit, featuring an integral mounting pad for continuous drive of a pump, generator, compressor or similar accessory. Developed by Bendix engineers, the new unit minimizes accessory mounting problems, eliminates the need for a gear box and provides efficient operation with reduced weight and better economy. You get continuous accessory drive during engine operation—and the design can be readily modified to cover a wide range of engine requirements.

Engine starting with this unit is automatic and cockpit-actuated. The engine is carried through light-off by the starter to the established cut-out speed. Then air flow to the turbine is automatically cut off and the unit's starter section coasts to rest, while the engine continues to drive the mounted accessory through the drive shaft and accessory pad gearing.

The starter is adaptable to high-temperature cross-bleed starting for multi-engine installations. It conforms to military specifications and has a minimum service life of 600 starts and 500 operational hours between overhauls. Safe operation is assured by self-limiting runaway speed and reverse overload release mechanism. It's easy to install and mount and provides reliable operation at extreme ambient temperatures.

ADDRESS ALL INQUIRIES TO:
Bendix Utica, 211 Seward Ave., Utica, N. Y.

West Coast: 117 E. Providencia, Burbank, Calif.
Canada: Aviation Electric Ltd., 200 Laurentien Blvd., Montreal, Que.
Export Sales and Service
Bendix International, 205 E. 42nd St., New York 17, N. Y.



Bendix Utica Division
UTICA, NEW YORK

Bendix AVIATION CORPORATION

Write in No. 220 on Reader Service Card at start of Product Preview Section

DATA PREVIEW

SELSYNS & SYNCHROS—GEA-6675, a 16-page bulletin discussing the complete line of electric selsyns and synchro electromagnetic devices used for extremely accurate transmission of electrical angular data between two or more points, is available from **General Electric, Dept. S/A, Fort Wayne, Ind.** Also included are, drawings, figures, tables, charts, and dimensions.

Write in No. 392 on Reader Service Card

SWITCHES—Rotary actuators, Series 6116M, and miniature linear actuators, Series 313 w/o switches, are described in Data Sheets 101-5 and 102-10, respectively. Both are available from **Lear, Inc., Dept. S/A, 110 Ionia Ave., N.W. Grand Rapids, Mich.** Features, engineering data, and installation drawings are included.

Write in No. 393 on Reader Service Card

GROUND SUPPORT EQUIPMENT—The LT-3783 continuously variable rate table, for use in overhaul depots, aboard aircraft and other facilities is available from **Lear, Inc., Dept. S/A, 110 Ionia Ave., N.W. Grand Rapids, Mich.** Specifications are also covered.

Write in No. 394 on Reader Service Card

THERMOCOUPLES—Magnesium oxide insulated, metal sheathed thermocouples and conductors which resist corrosion, abrasion, heat and shock, are described in the four-page bulletin available from **Tuttle & Kift Div., Ferro Corp., Dept. S/A, 1823 N. Monitor Ave., Chicago 39, Ill.**

Write in No. 395 on Reader Service Card

TRANSFORMERS—Its high temperature transformer designs and facilities are illustrated in Bulletin HT-325 published by **Acme Electric Corp., Dept. S/A, Cuba, N.Y.** These new electric transformers are for applications where ambient temperatures approach 350 deg C.

Write in No. 396 on Reader Service Card

RESOLVERS—Data Sheets 117-7 and 117-8, describing single and triple resolvers, series 2009C and series 2010C, respectively, are available from **Lear, Inc., Dept. S/A, 110 Ionia Ave., N.W. Grand Rapids 2, Mich.** Electrical and mechanical characteristics are included.

Write in No. 397 on Reader Service Card

DIGICORDER—Technical bulletin 102 explains how the digicorder, made by **Computer Equipment Corp., Dept. S/A, 1931 Pontius Ave, Los Angeles 25, Calif,** can be used to perform automatic data logging.

Write in No. 398 on Reader Service Card

more on page 294

for Communications

on the Missile Base Complex...

come to the experts!

DuKane electronic communication systems provide the vital network of instant voice communication which literally ties together such installations as Fort Churchill, Patrick AFB, and White Sands. DuKane offers the broadest, most flexible, most versatile line of custom-installed communication systems in the industry. For an installation involving a few persons, or hundreds, DuKane's experts can help you design and specify a communication system which will fill your needs. Why not ask for their help? *Write or wire DuKane Corporation, Dept. SA-5, St. Charles, Illinois*

If you specify electronic equipment, ask also for DuKane's chart of electronic equipment symbols.

DuKane Products are installed and serviced by a nationwide network of factory-trained experts

DuKane CORPORATION
St. Charles, Illinois

Job-engineered sound installations . . . Flexifone intercom systems . . . Private automatic telephone systems . . . Hospital communications systems . . . Ionovac hi-fi tweeters and ultrasonic generators . . . Sound slidefilm projectors for education and industry . . . Electronic production facilities for industry and for defense.

Write in No. 221 on Reader Service Card at start of Product Preview Section

Specify VARFIL SLEEVING and TUBING

and get these 5 BIG ADVANTAGES

Higher Dielectric Retention ● Greater Flexibility ● More Heat Resistance ● Available in Coils ● Can be After-Treated

AVAILABLE IN FOLLOWING NEMA CLASSES:

CLASS B-A-1
7000 Volts Average

CLASS B-B-1
4000 Volts Average

CLASS B-C-1
2500 Volts Average

CLASS B-C-2
1500 Volts Average

● Even under the most severe operating conditions, Varfil Sleeving and Tubing retains its average dielectric strength. Twist it, tie it, bend it, wrap it, knot it. Remains just as pliable as when you started. Won't crack, peel or suffer dielectric loss. Heat Varfil 2000 hours at 110° C.—1,000 hours at 125° C.—and even for extensive periods at 150° C. It won't break down. Can be after-treated in baking and varnishing operations. Reacts better than other oleoresinous materials and synthetic coated tubings. Available in handy coils so you can cut the exact lengths you need . . . no waste. Standard colors. Wide range of sizes. Send coupon today for free sample folder.

EXCEEDS OR MEETS ALL A.S.T.M. SPECIFICATIONS.

Varflex CORPORATION
Makers of Electrical Insulating Tubing and Sleeving

VARFLEX CORPORATION
500 W. Court Street, Rome, N.Y.

Please rush free folder containing samples of Varfil Sleeving and Tubing. Also include details on electrical tubing or sleeving you suggest using for

Name_____ Title_____

Company_____

Street_____

City_____ Zone_____ State_____

Write in No. 224 on Reader Service Card at start of Product Preview Section

DATA PREVIEW

HYDRAULIC COMPONENTS—A hydraulic pneumatic and vacuum catalog containing helpful information for engineering and maintenance departments, is available from **Lenz Co., Dept. S/A, Box 1044, Dayton, Ohio.** Complete data on ring seal tube fittings, flare fittings, pipe fittings, tube benders, and other hydraulic components are given.

Write in No. 399 on Reader Service Card

OIL LEAK DETECTOR—How you can detect oil leaks in minutes is illustrated in five steps in a four-page, two-color brochure from **Gilbreath Chemical Co., Dept. S/A, San Francisco, Calif.** Cook's leak detector, it is claimed, will detect leaks in hydraulic systems, fuel lines, fuel tanks and induction systems, and is capable of testing four to seven 225 hp aircraft engines.

Write in No. 400 on Reader Service Card

PLUG HARNESS—Catalog HC-1 is an eight-page publication that describes plug-terminated cables made by **Cannon Electric Co., Dept. S/A, P.O. Box 3765 Terminal Annex, Los Angeles 54, Calif.** The plug/harness systems are used in missile circuitry and other applications demanding unusual ruggedness and reliability of components.

Write in No. 401 on Reader Service Card

SEMICONDUCTOR – A Semiconductor Products Catalog describing their complete line is offered by **Bendix Aviation Corp., Semiconductor Products, Red Bank Div., Dept. S/A, Westwood Ave, Long Branch, N.J.** Also available at this time is a data sheet describing their type 1N1612 through 1N1616 5 ampere silicon rectifier series.

Write in No. 402 on Reader Service Card

CAMERAS—A rotating mirror camera and a rotating-drum camera for use in hypersonic tunnels, rocket-powered supersonic tunnels, shock tubes, and other applications have been described in bulletins by **Avco Research and Advanced Development Div., Dept. S/A, 201 Lowell St., Wilmington, Mass.** The mirror camera has a speed of four mm/usec, and the other, 0.19 mm/μsec.

Write in No. 403 on Reader Service Card

GYROS—The "Gyro Primer," a 165-page booklet on general gyro information, has been issued by **Norden Div., United Aircraft Corp., Dept. S/A, Commack, Long Island, N.Y.** Gyro nomenclature, operating principles, and specifications for rate gyros, free gyros, directional gyros, and compensated vertical gyros have been included.

Write in No. 404 on Reader Service Card

more on page 296

LOW LEVEL INPUT AMPLIFICATION

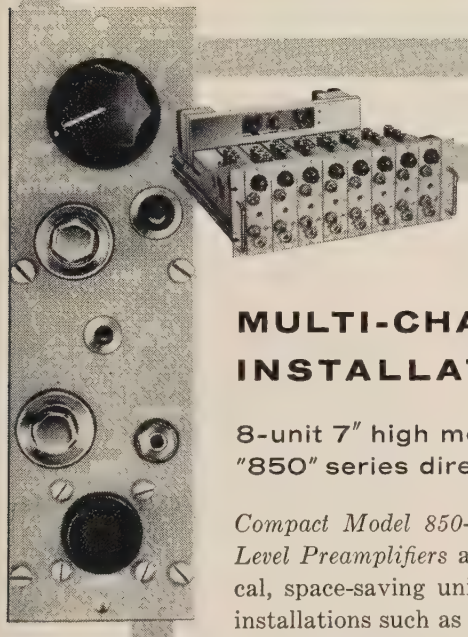
- *1,000,000:1 rejection ratio at 60 cps*
- *floating input*
- *isolated output*

IN 2 NEW SANBORN CHOPPER AMPLIFIERS

INDIVIDUAL SET-UPS

portable, self-contained unit amplifier

The Model 350-1500 Low Level Amplifier provides extremely versatile measurement of low level signals through use of two interchangeable plug-in circuits — one for thermocouple applications, another for DC strain gage work (other plug-ins now in development). Floating input and isolated output make the 350-1500 useful when signal measurements are made in the presence of large ground loop voltages. The 10-1/2″ high x 4-3/16″ wide 350-1500 may be used individually with its own power supply to drive a 'scope, meter, optical element, etc. or as a preamplifier in 6- or 8-channel 350 series recording systems.



MULTI-CHANNEL INSTALLATIONS

8-unit 7″ high modules for "850" series direct writers

Compact Model 850-1500A Low Level Preamplifiers are economical, space-saving units for large installations such as aircraft and missile development and test facilities where many recording channels are used to monitor strain gage and thermocouple outputs. Required 440 cps chopper drive voltages can be supplied for up to 16 channels with the *Model 850-1900 MOPA*.

SPECIFICATIONS

	350-1500	850-1500A
Sensitivity	20 uv input for 1 volt output, or 10 chart div. with Sanborn recorder; X1 to X2000 attenuator	100 uv input for 1 volt output, or 10 chart div. with Sanborn recorder; X1 to X200 attenuator
Input	Floating, can be grounded	
Input Impedance	100,000 ohms	200,000 ohms
Output	Floating or grounded (independent of input)	
Output Impedance	350 ohms	
Output Capabilities	±2.5 volts across 1000 ohm load	
Bandwidth	DC – 100 cps (3db)	
Linearity	±0.1% of full scale	
Common Mode Performance	120 db for 60 cps and 160 db for DC with 5000 ohms unbalance in source	
Noise	2 uv peak-to-peak over a 0 to 100 cps bandwidth	
Drift	±2 uv for 24 hours	
Gain Stability	±0.1% for 24 hours	

(specifications subject to change without notice)

Complete specifications and application data are available from Sanborn Sales-Engineering Representatives in principal cities throughout the United States, Canada, and foreign countries.

SANBORN COMPANY
INDUSTRIAL DIVISION
175 Wyman Street, Waltham 54, Mass.

Write in No. 225 on Reader Service Card at start of Product Preview Section

PRECISION PARTS—A 36-page brochure on its research development, testing, and production of precision prototype units, is available from **Sustrand Turbo, Dept. S/A, Pacoima, Calif.**

Write in No. 405 on Reader Service Card

FUEL CONTROL—Fuel Controls, systems, and aircraft pumps are described in its eight-page illustrated, technical brochure, by **Candler-Evans, Dept. S/A, West Hartford, Conn.** Its policy and services are also discussed.

Write in No. 406 on Reader Service Card

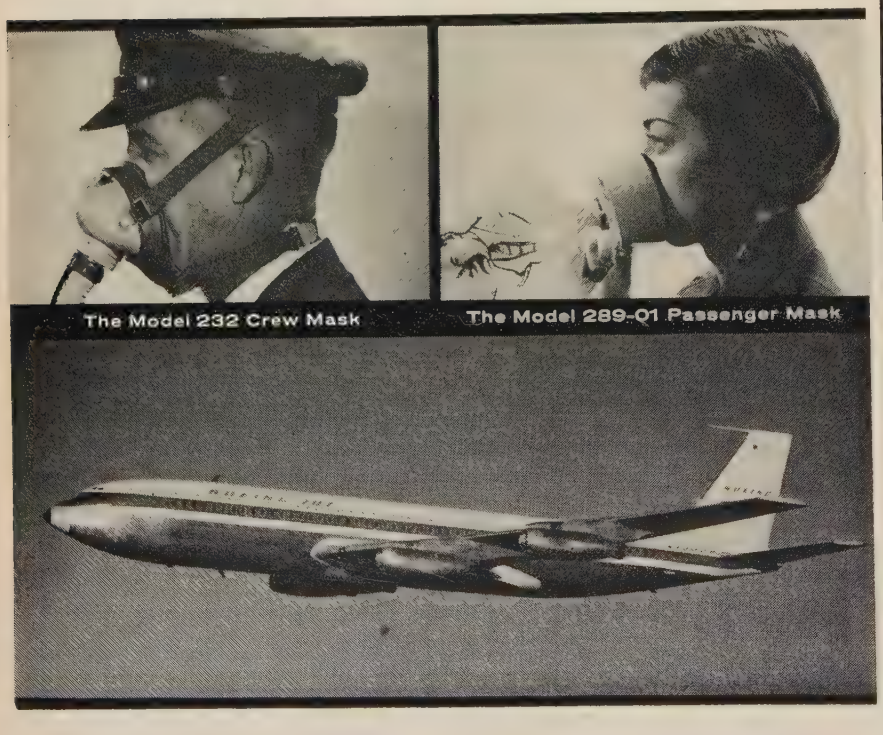
ENGINEERING—Facilities, personnel, welded products and control systems of **Research Welding & Engineering Co., Inc., Dept. S/A, 18201 South Santa Fe Ave., Compton, Calif.**, are described in their new publication.

Write in No. 407 on Reader Service Card

TESTING MACHINES—The high capacity of its testing machine is discussed and analyzed in a new 12-page brochure issued by **Tinius Olsen Testing Machine Co., Dept. S/A, 805 Eastern Rd., Willow Grove, Pa.**

Write in No. 408 on Reader Service Card

In case of emergency,
crew and passengers
DEPEND *on* **SIERRA®**
*personal emergency oxygen equipment**



Crews and passengers alike on many of America's new jetliner fleets will depend on Sierra Personal Oxygen Equipment—in case of emergency. Pioneer in personal oxygen gear, Sierra has produced a new and unique system which enables crew members to be individually fitted with a comparatively inexpensive oronasal mask which remains their personal property. The breathing tube, with microphone and valves remains permanently in the aircraft. In operation, the crew member simply attaches his mask to the breathing tube by means of a bayonet connector. An inexpensive, simple, yet effective breathing bag and universal face cup arrangement efficiently provides for passengers in case of emergency. You are invited to write for complete information. A technical paper reprint on oxygen mask suspension will be included.

**SIERRA CREW AND PASSENGER MASKS COMPLY WITH CAA REGULATIONS*

Sierra® ENGINEERING CO.

123 E. Montecito Sierra Madre, California

Write in No. 226 on Reader Service Card at start of Product Preview Section

HYDRAULIC PUMPS & MOTORS—A complete line of pumps and motors designed specifically for high temperature hydraulics systems is described in a four-page color brochure issued by **Pesco Products Div., Borg-Warner Corp., Dept. S/A, 24700 North Miles Road, Bedford, Ohio.**

Write in No. 409 on Reader Service Card

GERMANIUM DIODES—Bulletin 158 describing their line of gold-bonded germanium diodes is available from **Ohmite Mfg. Co., Dept. S/A, 3683 Howard St., Skokie, Ill.** Special computer types with 10 specified characteristics are also shown. These incorporate many superlative features for computer operation.

Write in No. 410 on Reader Service Card

CAPACITORS—A 16-page Ceramic Capacitor Cross-Reference Guide is available from **Globe-Union Inc., Centralab Div., Dept. S/A, 900 E. Keefe Ave., Milwaukee 1, Wis.** The Guide lists over 600 Centralab ceramic capacitors by type and rating.

Write in No. 411 on Reader Service Card

EXPLOSIVE PRODUCTS — Product specifications, performance data, description and illustrations on all its explosive ordnance products, explosive bolts, gas generators, pressure cartridges, igniters, squibs, initiators, destructors and other systems and devices, are contained in a new Technical Data book by **McCormick Selph Associates, Dept. S/A, Hollister Airport, Hollister, Calif.**, for company libraries, standards groups, and design groups in aeronautical and space field, and then to individual scientists and engineers.

Write in No. 412 on Reader Service Card

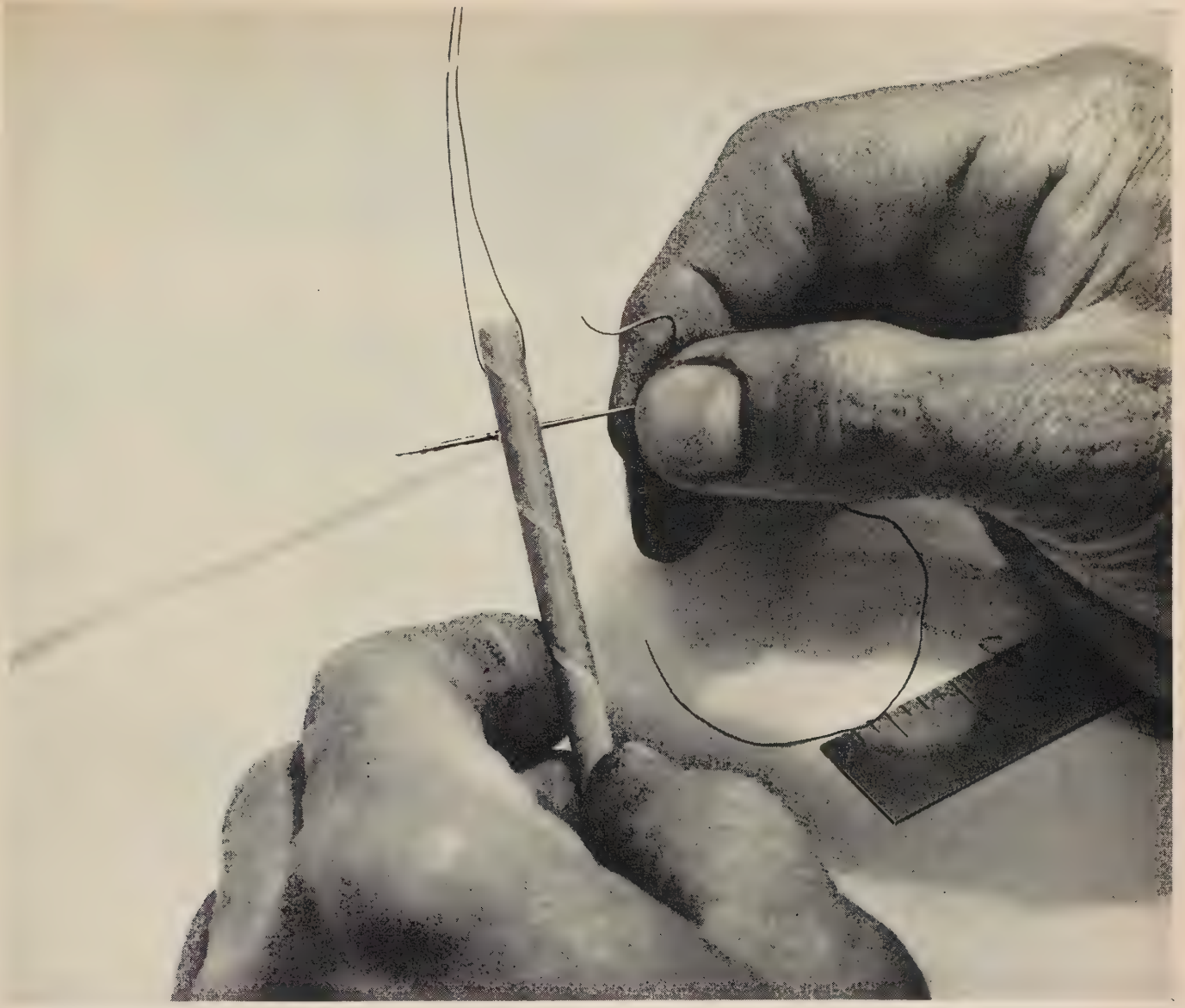
RESISTORS—Bulletin 162 describing three unusual assortments of precision resistors and tantalum capacitors marketed by **Ohmite Mfg. Co., Dept. S/A, 3670 Howard St. Skokie, Ill.** One assortment consists of tantalum wire capacitor, another of power precision resistors. Each assortment is offered in a handy 5-drawer, 40-compartment plastic case.

Write in No. 413 on Reader Service Card

MICROWAVE MEASUREMENTS — A 36-page application note describing the latest techniques and instrumentation for making various microwave standards measurements is available from the **Hewlett Packard Co., Dept. S/A, 275 Page Mill Rd., Palo Alto, Calif.** The booklet "Microwave Standards Prospectus" contains typical measuring arrangements devised by the engineering staff with many block diagrams and accuracy curves.

Write in No. 414 on Reader Service Card

more on page 300



How to Test a Solid Rocket Motor

In the early stages of research for new or improved propellants incongruous combinations of materials are often brought together in the chemistry laboratory—in this case, a common drinking straw, a strand of copper wire, a small batch of propellant and a sewing needle. The work shown here is a step in an experiment to test burning characteristics of a new high-energy propellant formula. The propellant, having been extruded into the straw, is threaded with a strand of copper wire. Later the "motor" is hooked into a specially designed apparatus that ignites the propellant and records and evaluates its performance.

From the igniting of grams of fuel in the chemistry labs to the test-firing of huge motors on the 2,000,000 lb. thrust test stands at THIOKOL's Utah facilities, research paces and supports every phase of the design, development and production of a rocket powerplant.

Through such research is coming the propellant formula that will give increased range to our ICBM missiles, and the tremendous power needed for spatial exploration.

In its Rocket and Chemical Divisions, THIOKOL boasts one of the finest scientific research teams in rocketry—an expanding group, continually in search of new members.

For qualified chemists, there exists stimulating work in **polymer research, in propellant analysis and formulation, in high vacuum techniques, and through the entire spectrum of high energy fuel.**

Doors are open, too, to research engineers and scientists with interest or experience in:

Solid State Physics, High Temperature Gas Dynamics, Electronics of Rocket Exhaust, Electromagnetics, Thermodynamics, Magnetohydrodynamics, Astronautical Systems Analysis, Ion and Plasma Propulsion, Nucleonics, and other phases of advanced propulsion work.

You'll work in areas that are good places to live—Denville, New Jersey; Huntsville, Alabama; Marshall, Texas; Moss Point, Mississippi; Brigham City, Utah; Trenton, New Jersey; Bristol, Pennsylvania. When you think of opportunity for yourself and your family, think of THIOKOL. Write to: Personnel Director at any plant address listed above.

Thiokol®

is Research to the Core

THIOKOL CHEMICAL CORPORATION
Bristol, Pennsylvania

®Registered trademark of the Thiokol Chemical Corp. for its rocket propellants, liquid polymers, plasticizers and other chemical products.

Write in No. 227 on Reader Service Card at start of Product Preview Section

THE HOUSE WHERE TOMORROW LIVES . . .

Our newest engineering facility, in Eatontown, New Jersey, is dedicated to creating new ideas and products that will help you meet tomorrow's electronic, missile and aircraft needs today.

This ultramodern, completely air-conditioned structure houses the most modern and exact testing devices. Fresh approaches to even the most complex engineering problems are encouraged and facilitated by an environment conducive to imaginative, creative thinking.

Bendix Red Bank's rapid growth since 1941 from a small maker of electrical devices to its present role as producer of a multitude of complex electrical and electronic systems is your added assurance that advanced engineering is a built-in Red Bank feature.

West Coast Office: 117 E. Providencia, Burbank, Calif.
Export Sales & Service: Bendix International, 205 E. 42nd St., New York 17, N. Y.
Canadian Affiliate: Aviation Electric, Ltd., P. O. Box 6102, Montreal, Quebec.

Red Bank Division
EATONTOWN, NEW JERSEY

Bendix
AVIATION CORPORATION

Write in No. 228 on Reader Service Card at start of Product Preview Section

Materials Memo

3M reports on a resilient, non-slip surfacing . . . oxygen safe lubricants . . . instrumentation data recorders

Many of the 27,000 different products manufactured by Minnesota Mining and Manufacturing—the 3M Company—have proved valuable in missile manufacturing and space research. Here is information on newer products — and up-to-date ideas and applications for some established products.

■ **SLIP-STOPPER:** For many years "Safety-Walk" Brand Non-Slip Surfacing, made by 3M's Coated Abrasives and Related Products Division, has been providing positive protection from slipping—everywhere from building entrances and shower stalls to heavy production areas.

Now the same degree of protection—plus resiliency and conformability—is available in a new product—"Scotch-Tred" Brand Non-Slip Surfacing . . . a flexible, abuse-resisting rubberized material on a tough plastic backing with a pressure-sensitive adhesive.

Our customers aren't satisfied with only walking on it. They're finding all sorts of new uses for it. Its anti-slip characteristics make it an excellent gripping surface; we've found it used around handles of tools, on load-bearing trucks and pallets and on pulleys. It's being applied temporarily to the surface of aircraft and missiles during the manufacturing operation. One customer puts it on the chassis of delicate electronic equipment during manufacture . . . to not only protect the equipment but also make it easier to handle. And, for the same reason, others apply it to materials handling equipment.

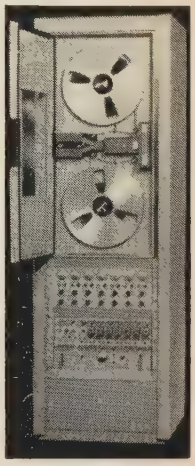
You can see samples of "Scotch-Tred" and discuss its fascinating possibilities by calling your local 3M Coated Abrasives salesman. Or, drop us a line and we'll do the rest.

■ **OXYGEN-SAFE LUBRICANTS:** Lubrication of moving parts in the presence of strong oxidants is no simple problem. But when the system contains liquid oxygen, with its enormous appetite for all organic compounds, the problem becomes really nasty! Our Chemical Division has worked up a series of oils and greases for this difficult processing situation. On missile launching pads, these "Kel-F" Brand products are giving service available from no other lubricants.

"Kel-F" oils, waxes, and greases have excellent load bearing characteristics, equivalent to a pure EP additive. They have excellent resistance to high humidity, are non-corrosive and can stand high temperatures, too. (Up to 500° F.) They are good not only for LOX, but for strong acids, including hydrofluoric and fuming nitric, alkalies, hydrogen peroxide, and aqua regia. GSE uses for the liquids includes compressor lubricants, hydraulic fluids, pump fluids, plug cock lubricants, and instrumentation lubricants. The high density (nearly twice that of water) of "Kel-F" oils makes them the first choice of gyro designers for flotation liquids.

Drop us a line if you'd like to have the complete story on these materials.

■ **ADVANCED TAPE DATA RECORDERS:** Just about everyone knows that 3M is one of the principal suppliers of magnetic tape, particularly for instrumentation and video recording uses. But not many people are acquainted with the fact that a 3M division also manufactures high quality instrumentation data recorders.



MODEL C-100

3M's Mincom Division in Los Angeles has announced a revolutionary new recorder—the Model C-100. It features all transistorized electronics; only 12 moving parts; instantaneous speed change without belt changing; push button selection of 6 different speeds, low reel tension, even when rewinding; low power requirements, so no cooling is necessary; up to 14 channels and up to 100 kc frequency response.

When you start planning that next data acquisition facility, why don't you contact Mincom and get acquainted with the newest thing in tape recorders?

P. S. They also have an advanced recorder/reproducer called the Mincom CV-100 which handles 7 one megacycle video channels on ½" tape.

■ **ABOUT "MIL":** 3M's Missile Industry Liaison is a service staffed by technical personnel experienced in rocket propulsion and other phases of space technology. Their job is to translate problems of the aerospace industry to those 3M specialists best qualified to solve them. If you have questions on any of the items mentioned here or would like to know what else 3M makes—or could make—for your needs, write: 3M Company, Missile Industry Liaison, St. Paul 6, Minn., Dept. VAA99.

DESCRIPTIVE BROCHURE shows cross-sample of 3M Products for Missile and space uses. For free copy, write: 3M Co., Missile Industry Liaison, St. Paul 6, Minn., Dept. VAA99.

"SAFETY-WALK", "SCOTCH-TRED" AND "KEL-F" ARE REGISTERED TRADEMARKS OF 3M CO., ST. PAUL 6, MINN.—EXPORT: 99 PARK AVE NEW YORK 16. CANADA: LONDON ONTARIO

Minnesota Mining and Manufacturing Company
. . . WHERE RESEARCH IS THE KEY TO TOMORROW

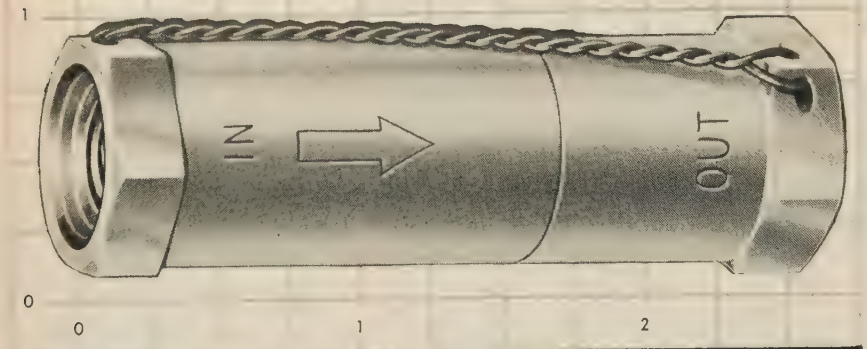
3M COMPANY

MISSILE INDUSTRY LIAISON

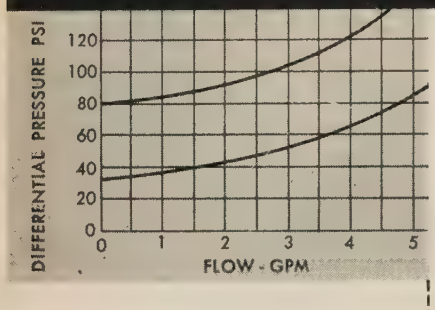
Write in No. 229 on Reader Service Card at start of Product Preview Section

Another FLUID REGULATORS Product

NEW RELIEF VALVE



- Fast Response
- Long Life
- Accurate Repeatability
- Light Weight



Typical Pressure — Flow Curve

Used in the directional control system of a missile, this small light weight valve was designed, manufactured, tested and delivered in just four weeks.

It can be custom built in a wide range of sizes and design variations to meet users specific size, weight and performance requirements.

Its another example of Fluid Regulators' ability to meet customers exacting specifications—from problem analysis thru delivery.

SPECIFICATIONS

- Cracking Pressure: 20 to 100 psi
- Proof Pressure: 300 psi
- Temperature: —65°F to +275°F
- Fluids: Hydraulic and fuel
- Internal Leakage less than MIL-V-5527A
- External Leakage: Zero
- Weight: 1.6 oz.
- Ports: AND 10050-6
- Material: Aluminum body, S.S. ball and spring
- Seat Construction: Soft or Stainless Steel
- Part No: 7513R—For Soft seat
  7513S—For Steel seat

Designers and manufacturers of hydraulic and fuel valves for aircraft missiles, rockets, ground handling and support equipment.

Fluid Regulators CORPORATION

313 GILLETTE STREET • PAINESVILLE, OHIO • ELmwood 2-3319

Write in No. 253 on Reader Service Card at start of Product Preview Section

CAPACITORS — A 16-page Ceramic Capacitor Cross-Reference Guide is available from **Globe-Union Inc., Centralab Div., Dept. S/A, 900 E. Keefe Ave, Milwaukee 1, Wis.** The Guide lists over 600 Centralab ceramic capacitors by type and rating.

Write in No. 415 on Reader Service Card

TELEMETRY DATA SYSTEM — The Mark I Basic Short Delivery Automatic PDM-to-Digital Computer Format Telemetry Data System, manufactured by **Epsco, Inc., Dept. S/A, 588 Commonwealth Ave, Boston, Mass.**, is described in a brochure now available. The entire PDM data to computer format process is completely automatic.

Write in No. 416 on Reader Service Card

RECTIFIERS—A 48-page silicon rectifier handbook containing electrical ratings, performance data and dimensional drawing for every type of silicon rectifier is offered by **Sarkes Tarzian, Inc., Rectifier Div., Dept. S/A, Bloomington, Ind.** Catalog 69 also deals with silicon rectifier theory and offers the design engineer valuable help in silicon rectifier application.

Write in No. 417 on Reader Service Card

IMAGE CONVERTER CAMERA—A 2-page brochure detailing their ultra-high speed image-converter camera is available from **Librascope, Inc., Dept. S/A, 66 South P Street, Livermore, Calif.** The camera is designed around a newly developed image-converter tube, electrostatically focused and deflected and is intended for the study of transient phenomena in the microsecond range.

Write in No. 418 on Reader Service Card

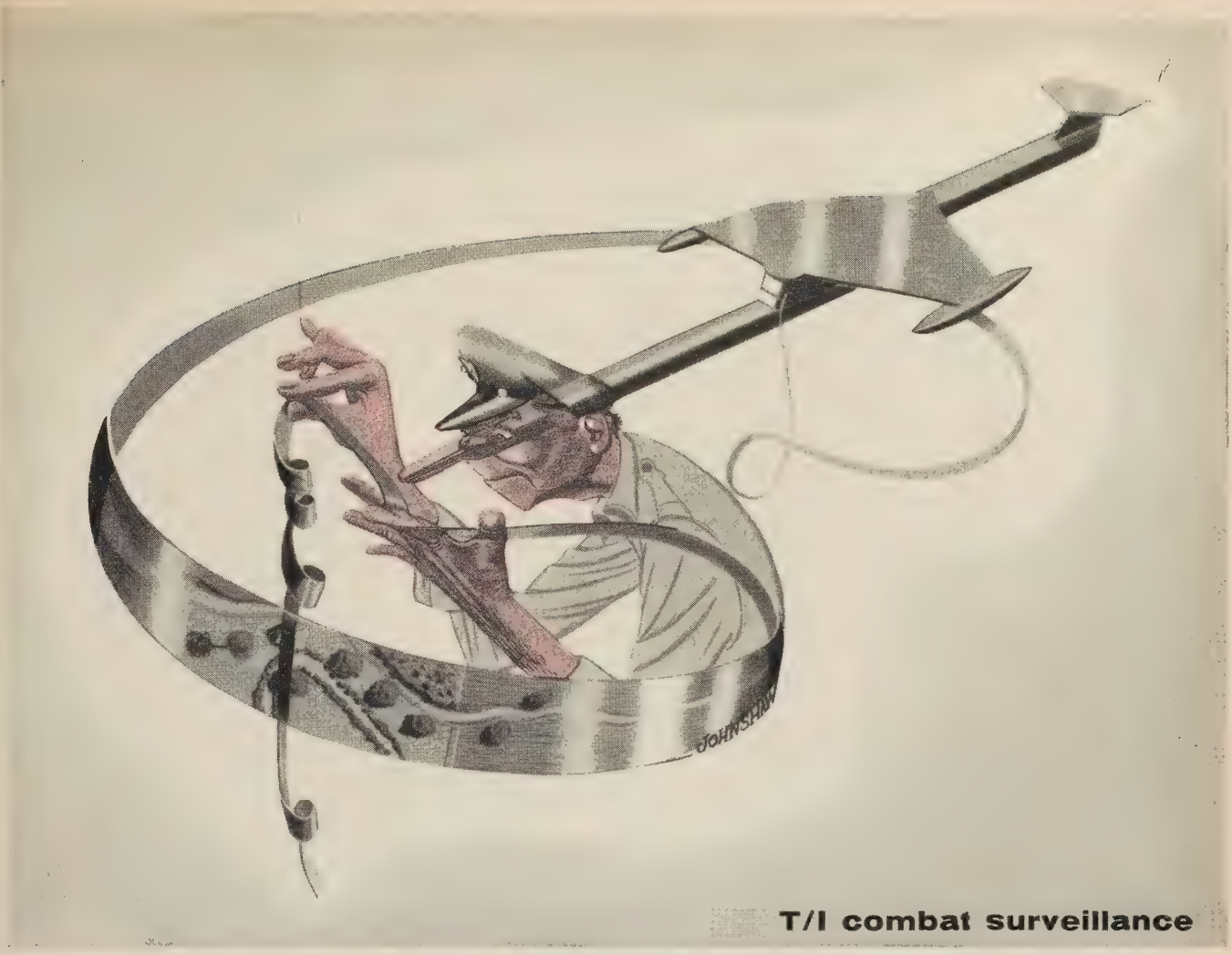
DATA PROCESSING—A 17-page booklet describing one of the most complete data processing and computation centers in the missile industry has been released by the **General Electric Co., Dept. S/A, Room 6A, 3198 Chestnut St., Philadelphia 4, Pa.** The booklet details the function and operations of the center's engineering groups.

Write in No. 419 on Reader Service Card

DIGITAL INSTRUMENTS — A short-form catalog describing three destinctly different lines of digital instruments for measurng AC and DC voltage, voltage ratio and resistance is available from **Non-Linear Systems, Inc., Dept. S/A, Del Mar, Calif.** Selection guides simplify selecting the instruments best suited for various applications.

Write in No. 420 on Reader Service Card

more on page 304



T/I combat surveillance

Stay 'home' and see more

Aggressor terrain and positions are open secrets to TI-equipped recon drones and snooper aircraft. Field commanders can now reconnoiter "in person" far behind aggressor lines *without leaving field HQ.* Instant, accurate, continuous data on thousands of sq mi of hidden territory can flow into headquarters *in the time one foot patrol could complete its mission.* Hundreds of targets can be spotted, evaluated and brought under fire in the same time interval . . . most of them within seconds after detection.

This capability exists now at Texas Instruments. For detailed discussion, military and industrial personnel with need to know please write or call: SERVICE ENGINEERING DEPARTMENT.

RESEARCH/DESIGN/DEVELOPMENT/MANUFACTURING of systems for: *Air traffic control • Airborne early warning • Antimissile • Antisubmarine warfare • Attack control • Countermeasures • Missile systems Navigation • Reconnaissance • Space electronics; and on detector cells, engine instruments, infrared, intercom, microwave, optics, sonar, telemetering, time standards, timers, transformers and other precision equipments.*

APPARATUS DIVISION

TEXAS INSTRUMENTS
INCORPORATED
6000 LEMMON AVENUE
DALLAS 9, TEXAS

Write in No. 230 on Reader Service Card at start of Product Preview Section

McDONNELL VOODOO

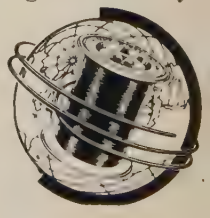
Above 1200 mph, it isn't enough to put just mechanical "muscle" at the pilot's command; he needs an assist with "mental" aerobatics, too.

Teaming-up with McDonnell engineers, the specialists of the Aeronautical Division at Minneapolis-Honeywell Regulator Company turned out a mechanical co-pilot specifically for the F-101B. For nerves and sinews in this M-H Autopilot, they specified Hitemp Teflon* coated wire and cable.

As the leading specialist in high temperature insulated wires and cables, Hitemp Wires, Inc. is proud to stand among those devoted to safeguarding our country.

HITEMP WIRES, INC.

1200 SHAMES DRIVE, WESTBURY, NEW YORK



Registered trademark for Du Pont fluorocarbon resins.

Write in No. 231 on Reader Service Card at start of Product Preview Section

produced by thermal decomposition

Disappointed with conventional magnesium oxides? Then try International's. *It's the only MgO produced by thermal decomposition.* And the difference is amazing! Electrically furnaced, this MgO has achieved the highest resistivity and refractory properties of any commercially available magnesium oxide.

You'll find International MgO relatively low in cost. Now improved production facilities are geared to produce any quantity you need.

For further details, fill out and mail the coupon . . . you can count on a prompt reply.

Here's how IMC does it!

CONVENTIONAL PROCESSES

↓

Magnesium Chloride $MgCl_2$
(Contained in sea water, well brine, bittern.)

+

Lime CaO
(Contained in dolomite, sea shells, etc.)

↓

Magnesium Hydroxide $Mg(OH)_2$ + heat

↓

Magnesium Oxide MgO

INTERNATIONAL'S UNPARALLELED PROCESS

Magnesium Chloride
$MgCl_2$ + heat

↓

Magnesium Oxide + Hydrochloric Acid
MgO HCl

↓

heat → MgO

And here's the result!

MgO	99.5%	Cl	0.03	Density .... 75 lbs./cu. ft.
S_1O_2	Nil	CaO	0.05	*Low Boron, too, upon request!*
SO_4	0.03	Fe_2O_3	0.05	

INTERNATIONAL MINERALS & CHEMICAL CORPORATION

Administrative Center: Skokie, Ill. • Phone ORchard 6-3000 • 485 Lexington Ave., New York 17 • Midland, Texas

Producers of Living Minerals

MINERALS International CHEMICALS

INTERNATIONAL MINERALS & CHEMICAL CORPORATION
POTASH INDUSTRIAL • Skokie, Illinois

This coupon will bring you complete descriptive data and specifications, plus a sample of (check one) . . .

☐ POWDERED MgO ☐ GRANULAR MgO ☐ PELLETIZED MgO

Name .....

Firm .....

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.....

41-59

Write in No. 232 on Reader Service Card at start of Product Preview Section

Now! get complete data on

MINIATURE AGASTAT®
time/delay/relays

This free folder contains complete specs on 24 models of the miniature AGASTAT Time Delay Relay for missile, aircraft, computer, electronic and industrial applications. They're small as 1-13/16″ x 4-7/16″ x 1½″, with adjustable timing ranges starting at .030 and as high as 120 seconds.

The folder gives operating and environmental specs, coil data, contact capacities, dimensions, diagrams of contact and wiring arrangements. *Write:* Dept. A33-919.

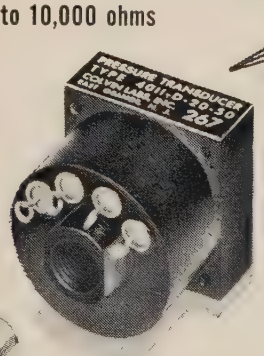
AGA DIVISION ELASTIC STOP NUT CORPORATION OF AMERICA
Elizabeth, New Jersey

Write in No. 233 on Reader Service Card at start of Product Preview Section

NEW MINIATURE PRESSURE TRANSDUCER BY COLVIN

- Only one inch square – one inch long
- Withstands high vibration

35 G to 5000 CPS 0-3 to 0-400 psi
400 to 10,000 ohms



AVAILABLE IMMEDIATELY

COLVIN LABORATORIES, INC.
364 Glenwood Avenue East Orange, N. J.

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Superb accommodations, full value and "snap-to" service

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THE BEVERLY CARLTON

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For immediate, confirmed reservations call: PLaza 9-6760 in New York
GRaystone 4-3600 in San Francisco
HOllywood 5-1131 in Los Angeles
MAin 3-6688 in Seattle
or Teletype LA 1840 in Los Angeles

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DATA PREVIEW

METAL PLATING—The new plasma arc service for metals in the high temperature range, is the subject discussed in an eight-page booklet from **Linde Co., Dept. S/A, 30 E. 42nd St., New York 17, N.Y.** This new torch has been used in connection with the manufacture of parts for missiles, rockets, electronic and nuclear components, and other parts used in civilian as well as military fields.

Write in No. 421 on Reader Service Card

PACKAGED CLEAN ROOMS—A four-page brochure from **Moore & Hanks Co., Dept. S/A, 9702 E. Rush St., El Monte, Calif.,** describes packaged clean rooms which are pre-fabricated and delivered to the customer's site ready for erection. Details are given on the control of contamination, temperature, and humidity, and the advantages of ease of enlarging or moving the structures is stressed.

Write in No. 422 on Reader Service Card

MEMORY SYSTEM—Bulletin 58-B describing Model 3122 Random Access Store is available from **Rese Engineering, Inc., Dept. S/A, 731 Arch St., Philadelphia 6, Pa.** In addition, timing diagrams complete specifications and application are included

Write in No. 423 on Reader Service Card

PHOTOCELL—An 8-page catalog #PC-649A entitled "Selenium Photovoltaic Cells" published by **International Rectifier Corp., Dept. S/A, 1521 E. Grand Ave., El Segundo, Calif.,** describes a complete line of self-generating photocells. Over 25 standard selenium cell types are described, including cell structure and operation, performance characteristics and typical applications.

Write in No. 424 on Reader Service Card

PUMPS—A new four-page folder, F-1251, describing four pumps for use with liquefied atmospheric gases, is available from **Linde Co., Dept. S/A, 30 E. 42nd St., New York 17, N.Y.** Performance ratings and specifications are included.

Write in No. 425 on Reader Service Card

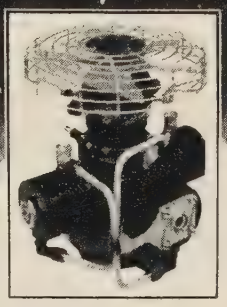
MISSILE SYSTEMS—A 36-page brochure describes a complete range of services in missile systems, covering **Cooper Development Corp.'s Dept. S/A, 2626 S. Peck Rd., Monrovia, Calif.,** capabilities in propulsion, electronics, telemetry, instrumentation, ground support, upper atmosphere research, meteorological studies, target systems and related activities. Engineering, production and quality control facilities are also discussed.

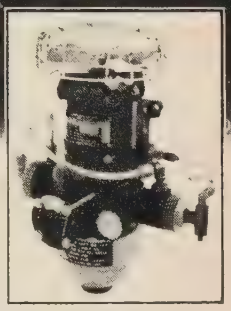
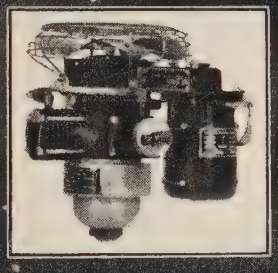
Write in No. 426 on Reader Service Card

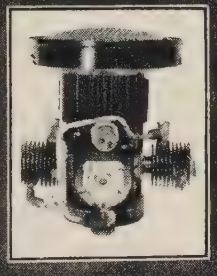
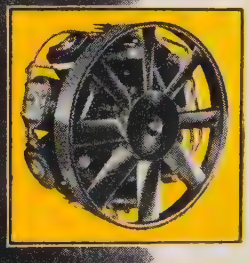
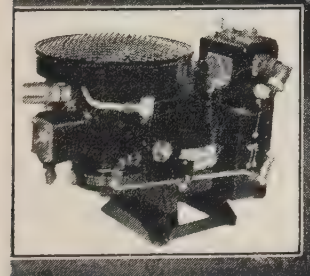
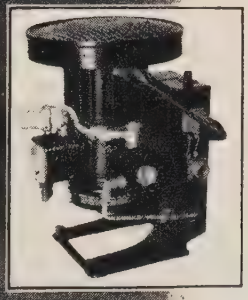
more on page 306

Cornelius

world's most popular airborne compressors...



It's no mere coincidence that Cornelius has manufactured more airborne compressors than all other makes combined – in fact, of all aircraft carrying compressors, 98% use Cornelius.

Engineers who specify them tell us the reason is clear: *Cornelius compressors have what it takes – efficiency-wise and performance-wise.* Model for model, they are the smallest, lightest and coolest running of any made. Cornelius compressors give you a choice of hydraulic, AC, DC, or engine drive. Some models weigh only 9 pounds *complete with motor.* They will deliver from 0.5 to 10 SCFM at pressures up to 3000 PSI, through a full range of altitudes and temperatures. 5000 PSI models are also available for special applications.

For complete information consult a Cornelius catalog or discuss your requirements with a Cornelius Sales Engineer. He has the experience and information that will save you time and money.

THE Cornelius COMPANY

557 – 39th Avenue N. E. • Minneapolis 21, Minnesota

*Photographs show but 10 of the 36 different Cornelius compressors available.

Cornelius

WHEN IT COMES TO COMPRESSORS . . . THERE IS NO SUBSTITUTE FOR EXPERIENCE

Write in No. 235 on Reader Service Card at start of Product Review Section

Convair 880 Utilizes Dependable Aeroquip Nets and Ratchet Buckles for Cabin Pressure Tests

Fuselage doors are protected with girdled net, securely tensioned with Aeroquip Ratchet Buckles (arrow).

Cockpit at right is protected with a specially made web harness, held in position with Ratchet Buckle straps.

AEROQUIP WEB NETS AND RATCHET BUCKLES SOLVE MANY FABRICATION PROBLEMS

At Convair Division of General Dynamics in San Diego, Aeroquip net harness systems are used in the production of the sleek new jet-powered 880. The special web nets are quickly tensioned on each new fuselage to protect personnel during cabin pressure tests. After testing, the nets are removed and reused on the next fuselage.

Whatever the operation, if you have to position or protect structural pieces in fabrication, you can do it better with Aeroquip nets or straps, and Aeroquip Ratchet Buckles. Mail the coupon below for full details.

Aeroquip
REG. TRADEMARK

GENERAL LOGISTICS DIVISION
2929 FLOYD STREET, BURBANK, CALIFORNIA SA-9

Please send full details on Aeroquip Web Nets and Ratchet Buckles

Name_____

Title_____

Company_____

Address_____

City_____ Zone_____ State_____

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DATA PREVIEW

VALVES—A new, 20-page, file-type catalog, No. 1159, covering products for dehydration, refrigeration; filters, driers and purifiers, vapor indicators and their technical details, is available from **Robbins Aviation, Inc., Dept. S/A, 2350 East 38th St., Los Angeles 58, Calf.**

Write in No. 427 on Reader Service Card

RECTIFIERS—A 16-page short-form catalog describing their line of 405 silicon and selenium rectifiers and diodes is available from **International Rectifier Corp., Dept. S/A, 1521 E. Grand Ave., El Segundo, Calif.** The publication gives ratings, electrical characteristics and engineering data.

Write in No. 428 on Reader Service Card

DELAY LINES—Manual TD58 "Procedures For Testing Delay Lines" is available from **Arenberg Ultrasonic Lab., Inc., Dept. S/A, 94 Green St., Jamaica Plain 30, Mass.,** at cost of 25 cents. The manual covers items ranging from basic inspection up to temperature effects and other variables.

Write in No. 429 on Reader Service Card

SERVOS—A 12-page booklet "Nomenclature for Rotating Servo Components" is available from **United Aircraft Corp. Norden Division, Ketay Dept., Dept. S/A, Commack, Long Island, N.Y.** Complete explanations of the symbols and definitions are included.

Write in No. 430 on Reader Service Card

TELEMETRY TRANSMITTER—A complete test report, detailing the results of tests performed on Model 86600 FM-FM Telemetry Transmitter, is available from **Gilfillan Bros., Inc., Dept. S/A, 1815 Venice Blvd., Los Angeles 6, Calif.**

Write in No. 431 on Reader Service Card

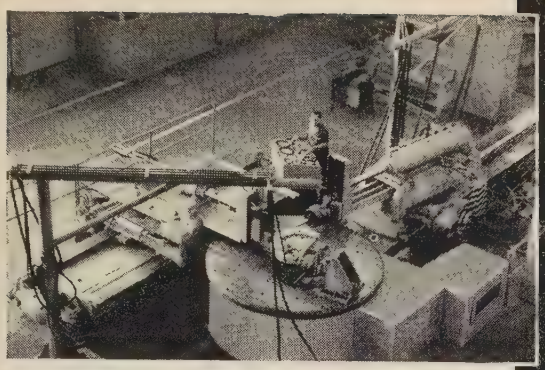
AMPLIFIERS—A 4-page brochure describing their Models DA102 and 103 low-level amplifiers, is available from **Epsco., Inc., Dept. S/A, 588 Commonwealth Ave, Boston, Mass.** The various options on these wide-band differential dc amplifiers is also described.

Write in No. 432 on Reader Service Card

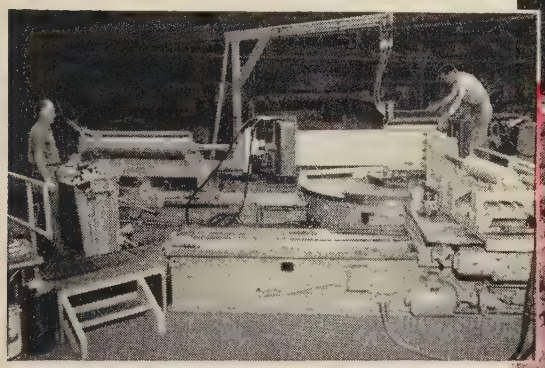
VIBRATION TESTING SYSTEMS—Three bulletins are available for use by aviation, missile, and rocket design and test engineers engaged in precise vibration analysis. Bulletin No. 425 covering vibration testing for sinusoidal and complex motion testing with force ratings from 1200 to 2500 lbs., and Bulletin No. 435, ratings from 1750 to 5000 lbs, and Bulletin No. 470, 7000 to 25,000 lbs are available from **MB Mfg. Co., Dept. S/A, P.O. Box 1825, New Haven 8, Conn.**

Write in No. 433 on Reader Service Card

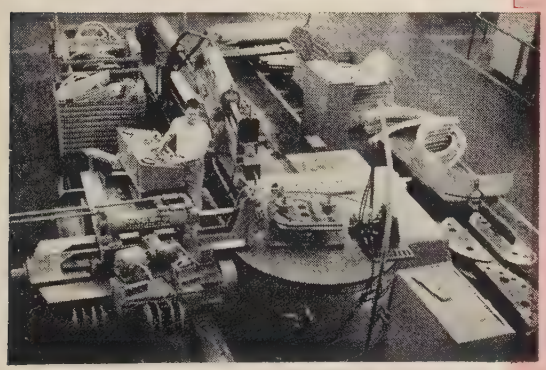
more on page 308



AT CONVAIR. This Model CF 25-50 Bath Radial Draw Former has produced hundreds of titanium and other critical parts for the F 102A and other programs at Convair.



AT DOUGLAS. Anti-icers, retainer seals, canopy rails, and many other parts for RB 66C, B 47 are Radial Draw Formed. DOUGLAS-TULSA STAFF PHOTO.



AT MARTIN. This Model CF 12 1/2-25 Bath Radial Draw Former forms titanium, stainless and aluminum parts for many of the Martin airplane and missile programs.

AIR PROGRESS THAT FIRES THE IMAGINATION . . .

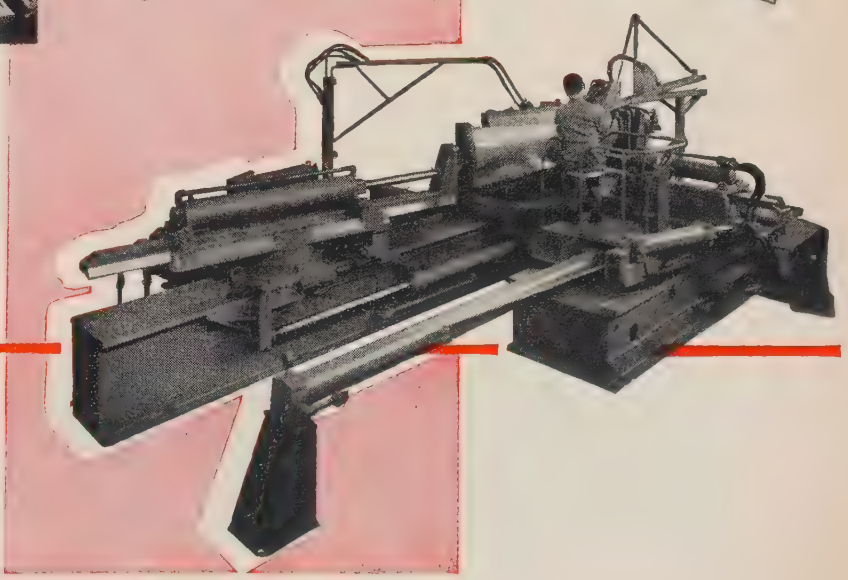
. . . and BATH radial draw formers are playing an important part

Great credit is due the aircraft, jet and missile industries for their fantastic progress in the last few years. The Aircraft Industry has taken us through the sonic barrier into the thermal thicket . . . truly, progress that fires the imagination. The titaniums, the inconels and other tough metals needed for this air progress yield best to forming by the BATH combined stretch and compression methods of Radial Draw Forming. One-piece construction in parts involving compound contours or changes in cross section throughout the contour have become possible with consequently greater strength and reduced weight.

The Cyril Bath Company is proud of the part they are playing in America's most progressive industry.

We will be pleased to send you our NEW Catalog describing the BATH Radial Draw Formers.

A Catalog describing the facilities of the Contract Forming Division is also yours for the asking.



THE CYRIL BATH COMPANY

32370 AURORA ROAD • SOLON, OHIO
(LOCATED IN THE GREATER CLEVELAND AREA)
Manufacturers of Radial Draw Formers • Dies • Tools
Press Brakes • Tangent Bending Sequence Presses • Press Type Brakes • Special Machines

Write in No. 237 on Reader Service Card at start of Product Preview Section

Aircraft engine oil strainer, one of many aircraft, automotive, marine and stationary engine parts cleaned and decarbonized by the new Narda Ultrasonic Vapor Degreaser—in less time and with less chemicals.

NEW!

NARDA Two-Stage, Low-Cost ULTRASONIC VAPOR DEGREASER

- *Better cleaning • up to 40 times faster!*
- *Increases reliability of all engines and systems*

This new production model SonBlaster® Vapor Degreaser, originally designed by Narda for the U. S. Air Force, is now commercially available—and at low cost! Thoroughly and quickly degreases and decarbonizes: oil and fuel strainers, pistons and rings, valves, spark plugs, carburetors, pumps, bearings and parts of all types.

The SonBlaster Vapor Degreaser is simple and economical to use. To degrease: place parts in (1) boiling sump and (2) ultrasonic sump (3) flush with power spray, using filtered and distilled pure solvent (4) condensing solvent vapor removes any residue traces—finished job is the ultimate in degreasing!

For additional information, please write to Dept. SA-5.

SPECIFICATIONS

Electrical Input: 208/230 volts, 50/60 cycles, 28/25 amps.

Generator: Delivers 300 watts average; 600 watts peak, 40 kc.

Transducer: Barium Titanate, 40 kc. Diaphragm, 112 sq. inches.

Recirculation System: ½ h.p. pump, stainless steel filter; 5000-watt heater, thermostatically controlled.

Valves: Pushbutton, solenoid-operated on all drains.

Cabinet: Cold rolled steel, baked enamel finish; 16 gauge, 302 stainless steel top. (All stainless steel cabinet optional at extra cost.) Over-all dimensions, 56" long x 32" high x 23½" wide.

Sumps: Over-all working area, 28" x 16", 14 gauge, 302 stainless steel, heliarc welded. Boiling sump capacity, 7¼ gals. Ultrasonic sump capacity, 6 gals. Distillate reservoir capacity, 2 gals.

Price: $2990 for above model. Other Narda Ultrasonic Vapor Degreasers from $1500.

the narda ultrasonics corporation

625 MAIN STREET, WESTBURY, L. I., N. Y. • EDgewood 3-5400
5785 North Lincoln Ave., Chicago, Illinois • LOng Beach 1-4625
3259 Wilshire Boulevard, Los Angeles 5, Calif. • DUnkirk 8-2201
Subsidiary of The Narda Microwave Corporation

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DATA PREVIEW

SECURING WIRE—A six-page, two-color, illustrated bulletin describing Cab-L-tite clamps, bund-L-tite straps, bundle-tie pliers, and wire hangers, is available from **Dakota Engineering, Inc., Dept. S/A, 4315-4317 Sepulveda Blvd., Culver City, Calif.** Properties are also listed.

Write in No. 434 on Reader Service Card

GYRO — A two-color brochure, describing the 2-gyro All Attitude Master Reference, is available from **Lear Inc., Dept. S/A, P.O. Box 688, Grand Rapids 2, Mich.** The unit is the simplest integration of gyro elements required to produce a complete all-attitude control reference.

Write in No. 435 on Reader Service Card

CERAMIC TRANSDUCERS—An eight-page, two color, illustrated brochure on its new series of high temperature, ceramic transducers is available from **Gulton Industries, Inc., Dept. S/A, 212 Durham Ave., Metuchen, N.J.** Applications and physical properties are included.

Write in No. 436 on Reader Service Card

COMPUTERS — A booklet describing the military capabilities of their computer department may be obtained by writing to the **General Electric Co., Dept. S/A, 1103 N. Central Ave., Phoenix, Arizona.** The booklet describes the facilities, as well as the products and services.

Write in No. 437 on Reader Service Card

MAGNETIC AMPLIFIERS — Bulletin #S-921 describing their standard line of low-level-linear magnetic amplifiers is available from **Magnetic Amplifiers, Inc., Dept. S/A, 632 Tinton Ave., New York 55, N.Y.** The bulletin furnishes complete performance specifications. Also included are detailed data on principles of operation and a characteristics curve chart.

Write in No. 438 on Reader Service Card

MICROWAVE CAPABILITIES—A compact 10-page brochure describing the company's facilities and capabilities is available from **Kearfott Co., Inc., Microwave Div., Dept. S/A, 14844 Oxnard St., Van Nuys, Calif.** The company is a leader in the field of development and production of precision microwave products.

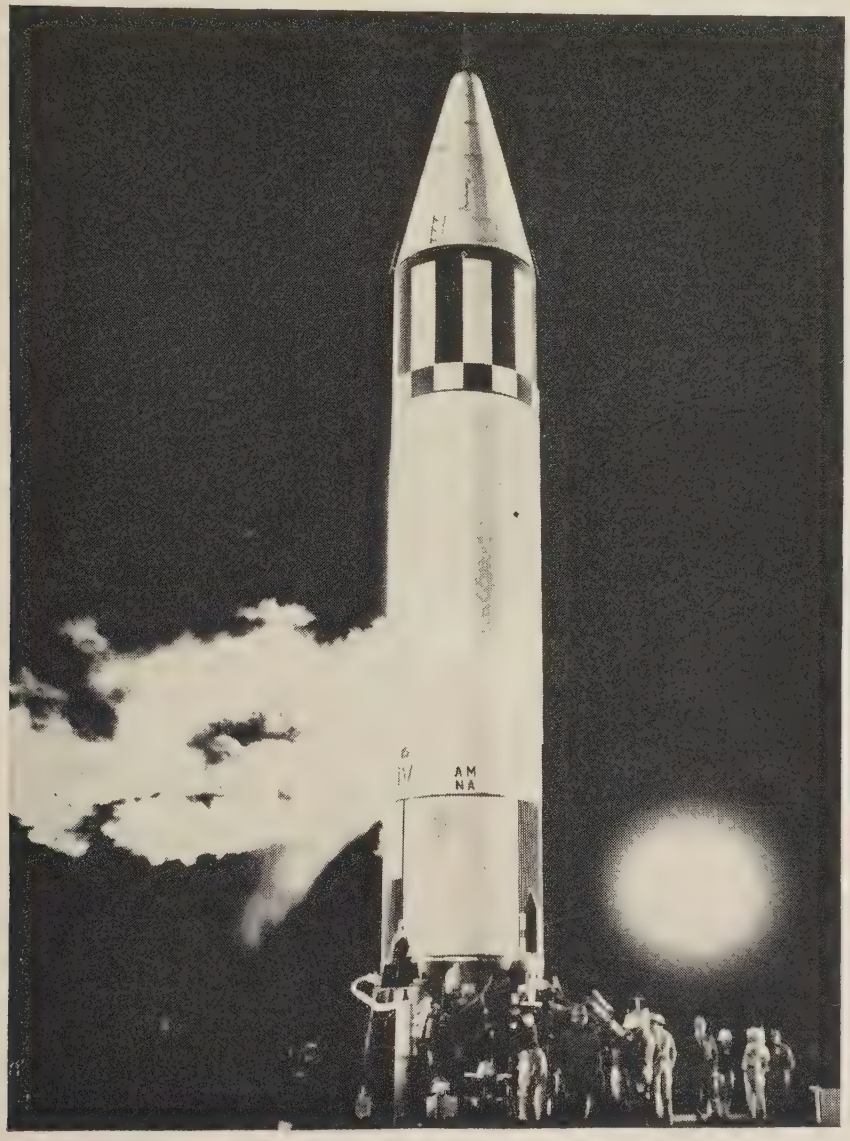
Write in No. 439 on Reader Service Card

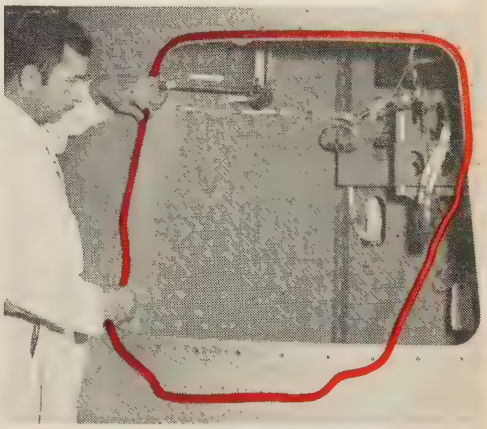
FANS & BLOWERS—initial copies of their 1959 catalogue are available from **McLean Engineering Lab., Dept. S/A, P.O. Box 228, Princeton, N.J.** Featured are package fans, blowers and accessory equipment used in conjunction with the cooling of electronic or electrical apparatus.

Write in No. 440 on Reader Service Card

more on page 310

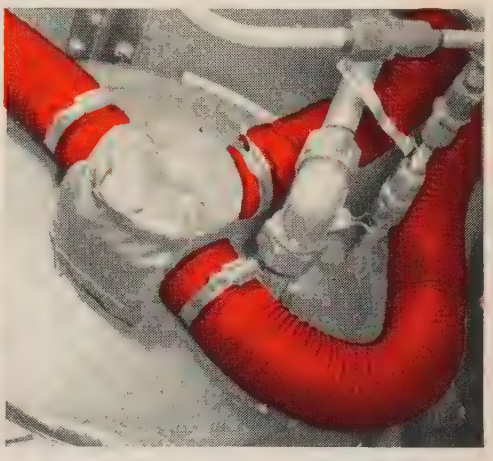
Sealing Zero...and 500 F





Silastic was specified for the Jupiter's instrument compartment access door seal. The Silastic seal has better storage properties and can better stand high skin temperatures. Wire bundle clamps in the compartment also utilize Silastic.

In the cooling system for Jupiter's instrument compartment, low pressure liquid nitrogen vapor is carried by these ducts. Made of Silastic and glass cloth, they're light in weight, and are designed to meet specs of —75 to 600 F performance.



SILASTIC SILICONE RUBBER withstands storage, cold, re-entry

Chrysler Missile Division engineers specify Silastic®, the Dow Corning silicone rubber, for flexible ducting, access door seals, and other applications on the Army-developed Jupiter IRBM.

Why Silastic? In the first place, of course, because this material has excellent resistance to extremes of temperature. From below —130 to 500 F, it remains rubbery and flexible. Re-entry temperatures far exceed 600, but Silastic survives for the brief period of time involved, whereas conventional rubber wouldn't.

Also, Silastic resists the effects of storage and weathering. Sample parts have withstood 9 years weathering at Florida test stations without measurable change of properties. This is equivalent to over 26 years of exposure under average storage conditions. Other reasons why missile designers specify Silastic include resistance to moisture, ozone, corona, many fuels and chemicals.

For further data, write dept. 0721.

Your nearest Dow Corning office is the number one source for information and technical service on silicones.

first in silicones

Dow Corning CORPORATION
MIDLAND, MICHIGAN

ATLANTA BOSTON CHICAGO CLEVELAND DALLAS LOS ANGELES NEW YORK WASHINGTON, D. C.

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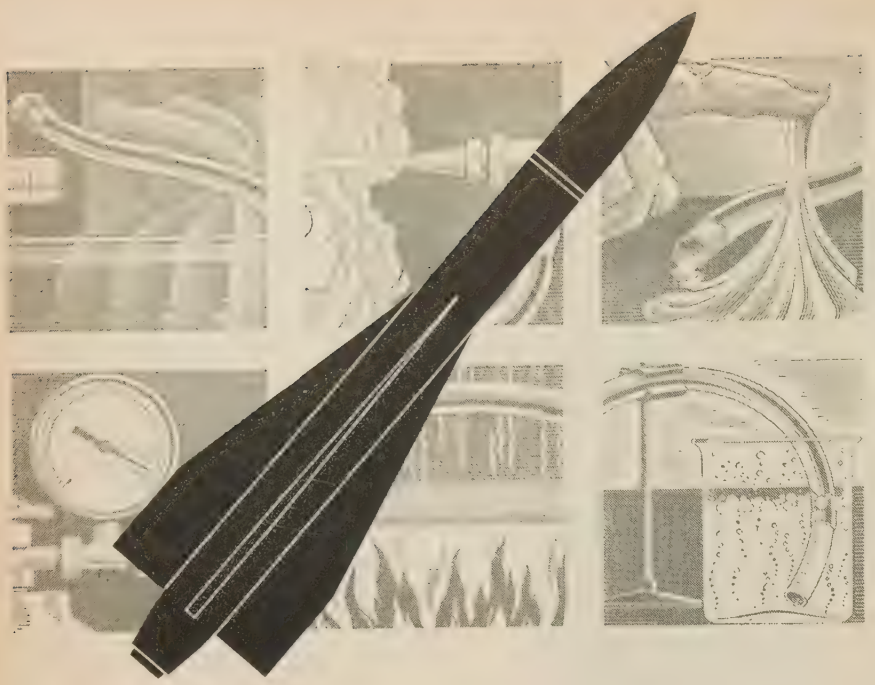
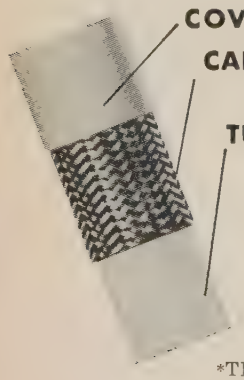


NEW MALTESE CROSS TEFLON HOSE WITHSTANDS OXIDIZERS AND ROCKET FUELS

Almost every aviation use is covered with this amazing new Hewitt-Robins TEFLON*-lined hose. It is ideally suited for fueling all kinds of rockets, missiles, and advanced aircraft . . . and because of its anti-hesiveness, it is easily and thoroughly cleaned for other uses. Its flexibility permits use on reels for compact ground support applications.

Here's a look at some other reasons its service life is many times that of conventional hose:



COVER of tough, abrasion resistant neoprene.

CARCASS of steel wire braid for strength and flexibility.

TUBE with high quality TEFLON lining.

Write today to Hewitt-Robins, Stamford, Connecticut, and ask for Bulletin 9-23-S-603.

AVAILABLE IN SOME SIZES IN LENGTHS UP TO 50 FEET

*TEFLON is a trademark of E. I. DuPont de Nemours & Co.

HR **HEWITT-ROBINS**

CONVEYOR BELTING AND IDLERS . . . POWER TRANSMISSION DRIVES
INDUSTRIAL HOSE . . . VIBRATING CONVEYORS, SCREENS & SHAKEOUTS

H-R Product Manufacturing Plants in Buffalo, N. Y. • Chicago, Ill. • King of Prussia, Pa. • Passaic, N. J. Amsterdam, Holland • Johannesburg, South Africa • London, England • Montreal, Canada • Paris, France

Write in No. 249 on Reader Service Card at start of Product Preview Section

DATA PREVIEW

CERAMIC – Technical Bulletin 118 describing high temperature, heat, and shock resistant ceramic, Duramic Grade HT-2-M, has been issued by **Duramic Products, Inc., Dept. S/A, 262-72 Mott St., New York 12, N.Y.** This ceramic is readily machinable for high temperature tooling with no further firing required.

Write in No. 441 on Reader Service Card

SCREWLOCK CONNECTORS—**Dejur-Amsco Corp., Dept. S/A, 45-01 Northern Blvd., Long Island City 1, N.Y.,** has available a technical bulletin with complete specifications and outline drawing on Continental's new series 1900 miniature rectangular connectors with center screwlock and closed entry contacts. These pin and socket connectors are designed for heavy duty applications in aircraft and electronic equipment.

Write in No. 442 on Reader Service Card

TRANSISTORS—Data sheets describing their Type 2N1008A, B and type 2N1073 diffused Alloy-Power Transistor series are available from **Bendix Aviation Corp., Semiconductor Products, Dept. S/A, Long Beach, N.J.** Bendix also offers complete information on their entire line of semiconductor products.

Write in No. 443 on Reader Service Card

SWITCHES & ACTUATORS—A complete bound reference catalog, ES-59, on basic switches and actuators has been published by **Electrosnap Corp., Dept. S/A, 4218 Lake St., Chicago, Ill.** Specifications, drawings, and modification information are given.

Write in No. 444 on Reader Service Card

CONNECTORS—A Technical Bulletin describes Series 200-19 terminal block, plug and socket type, and it is available from **DeJur-Amsco Corp., Dept. S/A, 45-01 Northern Blvd., Long Island City 1, N. Y.** Outline and mounting dimensions are included.

Write in No. 445 on Reader Service Card

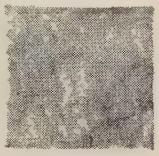
CONTROL SYSTEMS—**Farrand Controls, Inc., Dept. S/A, 4401 Bronx Blvd., New York 70, N.Y.,** has published an illustrated bulletin explaining the principles and applications of the Inductosyn, numerical control systems, entitled "Principles and Applications". Both the linear and rotary types available are described. Because of its versatility, the Inductosyn is used in many different fields such as, in precision servo systems; in automatic machine tool control; as a primary signal generator for shaft digitizers; as well as, in missile guidance applications and in fire control systems.

Write in No. 446 on Reader Service Card

more on page 312

REFRASIL

Highly efficient silica material for up to 2000° F. continuous, and higher temperatures for short duration use.



PHYSICAL FORMS:

- Batt • Bulk fiber
- Cordage • Cloth
- Sleeving • Tape • Yarn

APPLICATIONS

- Thermal and acoustical insulation
- Insulation for jet engines, rockets and missiles
- Industrial filtration
- Electrical insulation

METAL BLANKETS

HITCO metal blankets consist of envelope of stainless steel, Inconel or other metallic foil enclosing layer of insulating batt.

PRODUCTS:

- Flexible metal covered insulating blankets
- Pre-form metal covered insulating blankets

APPLICATIONS:

- Thermal and acoustical insulation
- Rocket and missile insulation

ELECTRIC BLANKETS

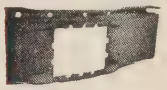
HITCO Insulation Blanket with built-in heating elements, and thermostatic controls.

APPLICATIONS

To control temperature of critical components or fluid systems. HITCO is capable of designing Electric Blankets to meet your specific requirements, using HITCO custom-designed heating elements.

THOMPSOGLAS

Molded high-density fiber glass for thermal, acoustical and vibration uses.



PRODUCTS:

- Compression pads
- Protective packaging liners
- Ducting insulation
- Thermal and acoustical insulation panels

APPLICATIONS:

- Packaging of delicate components
- Aircraft, rocket and missile ducting insulation
- Aircraft cabin insulation

ASTROLITE

Consists of Refrasil fibers combined with high temperature phenolic resin binders for short duration use up to 15,000°F.

PRODUCTS:

- Rocket nozzle entrance and exit cones
- Nose cones
- Deflector vanes
- Blast tubes
- Combustion chamber liners

APPLICATIONS:

Re-entry and ablation uses for:

- Rockets and missiles
- Spacecraft
- Earth satellites

HITCORE

Structural core materials of stainless steel, titanium and other weldable foils, in honeycomb form. Hitcore is machine-made lightweight welded metal honeycomb core material.

APPLICATIONS:

High temperature uses by sandwich-type structural panel manufacturers for aircraft and missiles.

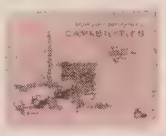
THE MISSILE MAKERS DESIGN WITH HITCO IN MIND!

You, as a Missile or Space Flight Scientist and Engineer, are engaged in the world's most exacting technology requiring high temperature materials.

Your contribution to the advancement of the art sometimes depends upon the availability of materials which have extraordinary insulation ability.

HITCO is one of the world's leading developers and manufacturers of thermal materials capable of performing in temperature extremes from −300° F. up to 15,000° F!

Our R & D Engineers are ready to consult with you now, without obligation, of course. For peace of mind in the solution of your insulation problems, keep HITCO in mind in your Missile Design!



Call or write us for interesting new Capabilities Brochure and complete Technical Data on any of the HITCO Products described above

H. I. THOMPSON FIBER GLASS CO. *1733 Cordova Street • Los Angeles 7, Calif. • REpublic 3-9161*

WRITE OR CALL YOUR NEAREST HITCO REPRESENTATIVE: **EASTERN:** Tom Kimberly, 38 Crescent Circle, Cheshire, Conn., BR. 2-6544; Fred W. Muhlenfeld, 6659 Loch Hill Rd., Baltimore 12, Md., VA. 5-3135 • **MIDWEST:** Burnie Weddle, 3219 W. 29th St., Indianapolis 22, Ind., WA. 5-8685 • **SOUTHWEST:** Marshall Morris, 2850A W. Berry, Rm. 7, Fort Worth, Tex., WA. 4-8679 **NORTHWEST:** J. L. Larsen, 5757 Oaklawn Pl., Seattle, Wash., PA. 5-9311 • **CANADIAN PLANT:** THE H. I. THOMPSON CO. OF CANADA LTD., 60 Johnston St., Guelph, Ont., TA. 2-6630

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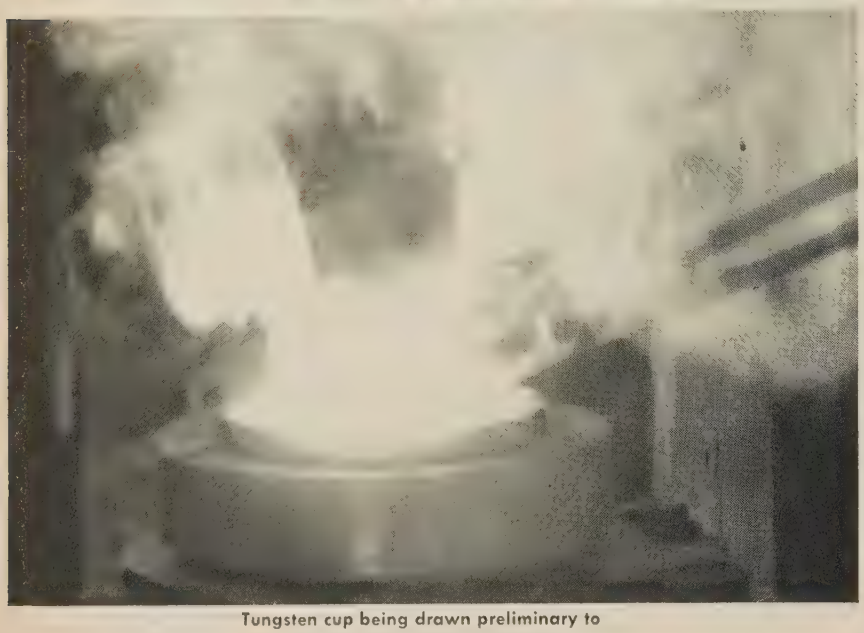
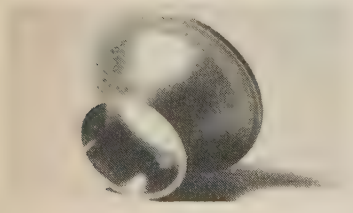
LOOK WHAT FANSTEEL'S DOING WITH TUNGSTEN NOW!



Tungsten cup being drawn preliminary to shaping into missile hardware.



BIGGER TUNGSTEN NOZZLE THROAT INSERTS

Now made up to 4" flange diameter, 3" long, with wall thicknesses of 0.060"! Incredible six months ago... possible today ... routine tomorrow at Fansteel!

AND . . . THESE TUNGSTEN CUPS NOW AVAILABLE FROM EXISTING DIES:

Fansteel will help you investigate the possibility of adapting Tungsten in your product. Call in the Fansteel man.

- 13/16" I. D. x .060" wall x 1¼" deep
- 1¾" I. D. x .060" wall x ½" deep
- 1½" I. D. x .060" wall x ⅝" deep
- 1 5/16" I. D. x .125" wall x ¾" deep
- 1 5/16" I. D. x .125" wall x ⅞" deep
- 1⅛" I. D. x .040" to .060" wall x 2 5/16" deep
- 2" I. D. x .060" to .080" wall x 5" deep
- 2⅝" I. D. x .125" wall x 2⅝ deep
- 3 5/16" I. D. x .125" wall x 1⅞" deep
- 4½" I. D. x .125" wall x 1¼" deep

FANSTEEL HIGH TEMPERATURE METALS

FANSTEEL METALLURGICAL CORPORATION North Chicago, Ill., U.S.A.

Write in No. 243 on Reader Service Card at start of Product Preview Section

DATA PREVIEW

PRESSURE TRANSDUCER—A new catalog describing pressure transducer, Model S-30, gives applications, specifications, drawings and pressure fittings. It is published by **Ultradyne, Inc., Dept. S/A, P.O. Box 3308, Albuquerque, N.M.**

Write in No. 447 on Reader Service Card

POTENTIOMETERS — A 4-page brochure summarizing information on their TRIMPOT R and Trimit R lead screw actuated potentiometers has been announced by **Bourns Laboratories, Inc., Dept. S/A, P.O. Box 2112, Riverside, Calif.** The bulletin features a specification table listing avalable resistances, operating temperatures and dimensions of popular models.

Write in No. 448 on Reader Service Card

40-MICRON FILTERS—A new, two-page, two-color engineering data sheet, No. 101, describing a line of 40-micron breather filters for free flow of clean air into hydraulic fluid, fuel and oil reserves is available from **Bendix Filter Div., Bendix Aviation Corp., Dept. S/A, 434 W. 12 Mile Rd., Madison Heights, Mich.**

Write in No. 449 on Reader Service Card

RELIEF VALVE—A new engineering bulletin giving complete details, specifications and operational features of a new, large capacity relief valve designed especially for ground handling and support equipment is available from **Fluid Regulators Corp., Dept. S/A, 313 Gillette St., Painesville, Ohio.** The new pilot operated relief valve is designed to control pressure in hydraulic, lubricating and fuel systems.

Write in No. 450 on Reader Service Card

INSULATED WIRES—The 1959, 64-page, high temperature catalog on teflon insulated wires and cables is available from **American Super-Temperature Wires, Inc., Dept. S/A, Winooski, Vermont.** The publication contains eight sections of the latest engineering information and prices on high-temperature magnet wire, lead wire, cables, tubing, and teflon tape, and offers quick, easy reference on military specifications, temperature ranges, wire and cable constructions, colors, tests, etc.

Write in No. 451 on Reader Service Card

MAGNETIC AMPLIFIERS—A 16-page Magnetic Amplifier Design Manual #403-A describing magnetic amplifier design and application techniques is available from **Acromag Inc., Dept. S/A, 22519 Telegraph Rd., Detroit 41, Mich.** Some of the topics covered are: Signal mixing, voltage and current comparators, LaPlace Transforms, Velocity Servos, etc.

Write in No. 452 on Reader Service Card

more on page 314

this rugged Video Telemetering System

THIS REMARKABLE NEW television system gives you the power of sight where human eyes cannot go. It can be directed outward for observation, or inward to "watch" internal operation from a range of 1,000 miles line-of-sight.

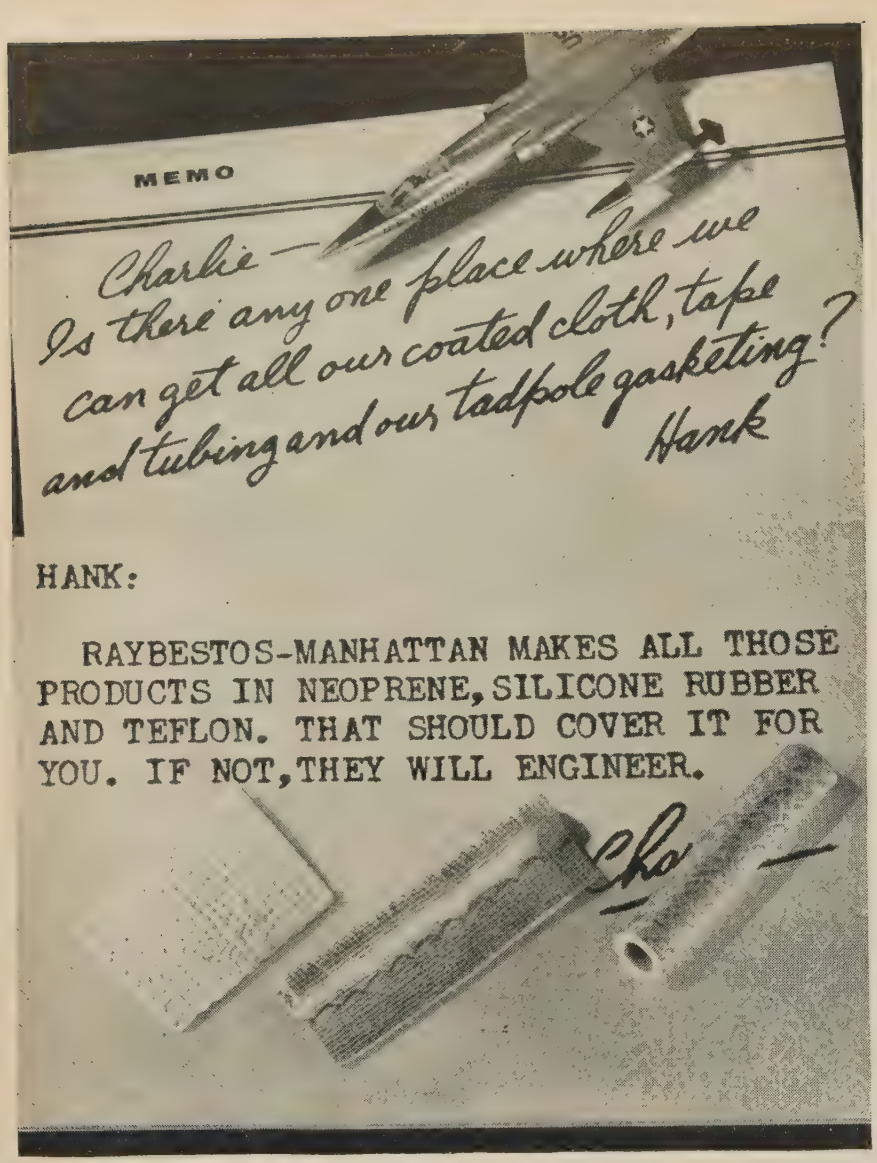
Capable of operation under extreme environmental conditions, and packaged for use under conditions requiring limited space, weight, and power, the Model 701 includes such features as: transistorized circuitry, 525 line, 30-frame fully interlaced picture, crystal controlled EIA synch, and high sensitivity.

Weight of the complete unit is under nine pounds. Total volume is less than 119 cubic inches. Its critical-design requirements are typical of all *LEAD* products. Each can be modified to meet many different requirements. Tell us what yours are. Contact our Marketing Branch, Lockheed Electronics & Avionics Division, 6201 E. Randolph St., Los Angeles 22...OVerbrook 5-7070.

Requirements exist for staff and supervisory engineers

LOCKHEED ELECTRONICS & AVIONICS DIVISION

Look to Lockheed for LEADership in Electronics


MEMO
Charlie —
Is there any one place where we can get all our coated cloth, tape and tubing and our tadpole gasketing?
Hank
HANK:
RAYBESTOS-MANHATTAN MAKES ALL THOSE PRODUCTS IN NEOPRENE, SILICONE RUBBER AND TEFLON. THAT SHOULD COVER IT FOR YOU. IF NOT, THEY WILL ENGINEER.
Cho —

You can rely on the engineering skill and experience of R/M when you are looking for coated cloth and tape, coated tubing, and gasketing materials for a wide range of applications in the aviation field. For example:

Coated cloth and tapes—Neoprene for resistance to high temperatures, oil, water, steam, ozone; silicone rubber for weather resistance and outstanding flexibility for long periods; "Teflon"* coated glass cloth for nonadhesive properties, remarkable resistance to all solvents and acids, heat resistance.

Coated fabric tubing—available in Neoprene, silicone rubber, and "Teflon" and offering all the advantages of these materials.

Tadpole gasketing—engineered by R/M to meet the needs of the aviation industry in many different applications, including the sealing of jet engine firewalls. Neoprene, silicone rubber, "Teflon."

R/M engineers have amassed a wealth of experience in manufacturing coated fabrics, packings and gasket materials for aviation as well as many other industries. Whether you are concerned with manufacturing or maintenance, this experience is at your disposal. Call on R/M for more information and literature.

*A Du Pont trademark

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PACKING DIVISION, PASSAIC, N.J.
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RAYBESTOS-MANHATTAN INC.. Mechanical Packings • Asbestos Textiles • Industrial Rubber • Engineered Plastics Sintered Metal Products • Abrasive and Diamond Wheels • Rubber Covered Equipment • Brake Linings Brake Blocks • Clutch Facings • Industrial Adhesives • Laundry Pads and Covers • Bowling Balls

Write in No. 244 on Reader Service Card at start of Product Preview Section

TRANSDUCERS—Ramapo Instrument Co., Inc., Dept. S/A, 8 First St., Bloomingdale, N.J., has published a new, four-page brochure on its Mark V Flow Transducer, which is specifically designed for the measurement of single or bi-directional flow.

Write in No. 453 on Reader Service Card

MEASUREMENT SYSTEMS—Bulletin GEA-6788, a 15-page brochure, describes G. E.'s Aircraft Electric-Quantity Measurement Systems. This text from **General Electric Co., Dept. S/A, Schenectady 5, N.Y.,** includes photographs, construction and operation details, dimension and connection drawings, and specifications and ratings for new advanced design airborne ac and dc panel instruments with integral lighting capability, standard design ac and dc panel instruments, aircraft instrument current transformers and ground maintenance equipment.

Write in No. 454 on Reader Service Card

PULSE COUNTER—A bulletin describing their Model CN-1A1 Count Limiter is available from **Abrams Instrument Corp., Dept. S/A, 606 E. Shiawassee St., Lansing, Mich.** The unit is basically a predetermining pulse counter and stop control for 28 V dc use. A large detented knob and dial scale permit easy setting of any number from 1 to 120.

Write in No. 455 on Reader Service Card

FLEXIBLE SHAFTS—Bulletin No. 590 gives design data on the new high speed power drive flexible shafting. This bulletin, from **Stow Manufacturing Co., Dept. S/A, 443 State St., Binghamton, N.Y.,** gives information on the torque ratings in different bends and the maximum operation speeds as well as dimensional data on all sizes.

Write in No. 456 on Reader Service Card

SUBMINIATURE MECHANISM—A technical data sheet describing its versatile subminiature servo mechanism, Model 20-200, for use as a complete hermetically sealed integrally lighted airborne indicator, analog computer element, or control device, is published by **Servo Development Corp., Dept. S/A, 567 Main St., Westbury, Long Island, N.Y.**

Write in No. 457 on Reader Service Card

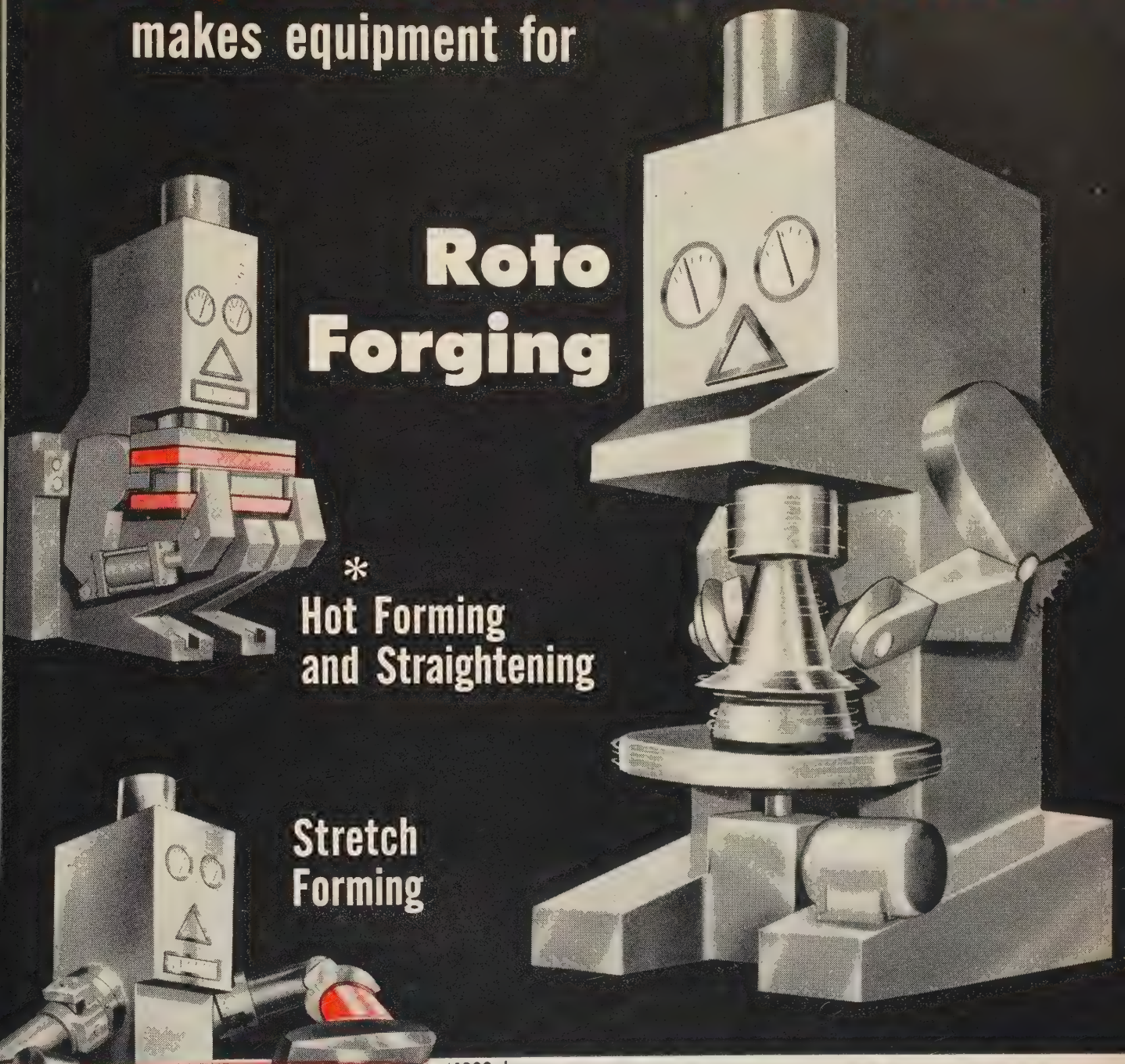
DATA PROCESSING—Brochure S-526 R1 gives specification, basic features, components and application of the LGP-30 General Purpose Computer manufactured by **Royal McBee Corp., Data Processing Div., Dept. S/A, Port Chester, N.Y.** Operation of the control panel and simple 16-part Command Table is described.

Write in No. 458 on Reader Service Card

more on page 316

Clearing Aircraft and Missiles Division

makes equipment for



Roto Forging

* Hot Forming and Straightening

Stretch Forming

*1800 degrees

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Main Plant: 6499 W. 65th St. • Chicago 38, Illinois • PO7-8700
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CIRCUIT BREAKERS—Wood Electric Co., Dept. S/A, 244 Broad St., Lynn, Mass., who specialize in circuit protection problems, has issued a simplified circuit breaker catalog. Specifications and construction details arranged to save time for the engineer in search for the right circuit breaker for a particular application.

Write in No. 459 on Reader Service Card

LIMIT SWITCHES—A 16-page catalog #84 covering a complete line of heavy duty Limit Switches has been published by **Minneapolis Honeywell Regulator Co., Microswitch Div., Dept. S/A, Freeport, Ill.** It lists switches with a variety of contact arrangements, for either direct- or alternating-current applications.

Write in No. 460 on Reader Service Card

DIFFERENTIAL TRANSFORMERS — Literature on the applications of linear variable differential transformers is available from **Schaevitz Engineering, Dept. S/A, Route 130 & Schaevitz Blvd., Pennsauken, N.J.** Bulletins include information on the use of LVDT'S with universal analyzers, null balance systems, rectifier diodes, strain gage amplifiers and in the measurements of very small displacements.

Write in No. 461 on Reader Service Card

MINIATURE BALL BEARINGS—Conversion tables giving other manufacturers' numbers for miniature ball bearings are featured in a bulletin from **Landis & Gyr, Inc., Dept. S/A, 45 W. 45th St., New York 36, N.Y.** This bulletin illustrates and describes filmoseal miniature ball bearing to ABEC-1 and ABEC-5 tolerances.

Write in No. 462 on Reader Service Card

THERMOCOUPLE PROBE—A new bulletin, EDS-36, describing its cermet shielded, high-temperature thermocouple probe is available from **Thermo Electric Co., Inc., Dept. S/A, Saddle Brook, N.J.** A perforated sheet is attached for user to return to Thermo for engineering evaluation and custom design.

Write in No. 463 on Reader Service Card

METAL HOSE—Free literature and full information on all industrial applications of flexible metal hose and components are available from **U. S. Flexible Tubing Co., Dept. S/A, Bartlett, Ill.** Individual folders cover particular industries or specific products. It is suggested that the inquirer define the use and/or conditions under which the hose, bellows, ducts or assemblies will serve.

Write in No. 464 on Reader Service Card

SERVOVALVES — Catalog 150, published by **Moog Valve Co., Inc., Dept. S/A, East Aurora, N.Y.,** describes operating principles, design features and performance characteristics of its line of pressure control servovalves. Typical applications are aircraft and missile control systems and industrial installations for automatic machine tools and testing machines.

Write in No. 465 on Reader Service Card

DATA REDUCTION—A brochure describing their automatic telemetry data reduction systems is available from **Epsco Inc., Dept. S/A, 588 Commonwealth Ave, Boston, Mass.** The systems will automatically reduce FM, PAM, PDM and even PCM telemetry data into magnetic tape format compatible with digital computers in use today.

Write in No. 466 on Reader Service Card

LIQUID GAS CONTAINERS—A six-page folder, describing a complete line of small containers for the transport and storage of liquefied gases, is available from **Linde Co., Dept. S/A, 30 East 42nd St., New York 17, N.Y.**

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more on page 322

JUST OUT!
NEW 1959 EDITION

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CATALOG

One Complete Source of Detailed Specifications for Designers, Production Managers, Toolroom Foremen

Hundreds of NEW ITEMS

ALL NEW — Complete specifications and cost saving data on over 2000 "Standards", including world's largest line of work-holding equipment, chuck jaw blanks, handles, knobs, wheels, strap clamp assemblies, forged items, plus hundreds of other jig and fixture components. Detailed specifications, engineering drawings. The one complete source for data on all the "standards" for tool, die, jig, and fixture design and application. Write for your FREE copy today. Dept. SA.

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712 East 163 St., Cleveland 10, Ohio

Write in No. 246 on Reader Service Card

What is your **MISSILE FASTENING PROBLEM?**

Delron's NEW ENGINEERING DATA MAY HAVE THE ANSWERS!
Our 48-page Catalog of Specialized Fastening Devices for High Temperatures and Sandwich Panel Fastening can help you select the right Fastener for your Missile Applications.

★ Write for your copy today!

...Fastener Specialists!

THE DELRON COMPANY, INC.
5224 Southern Avenue, South Gate, California
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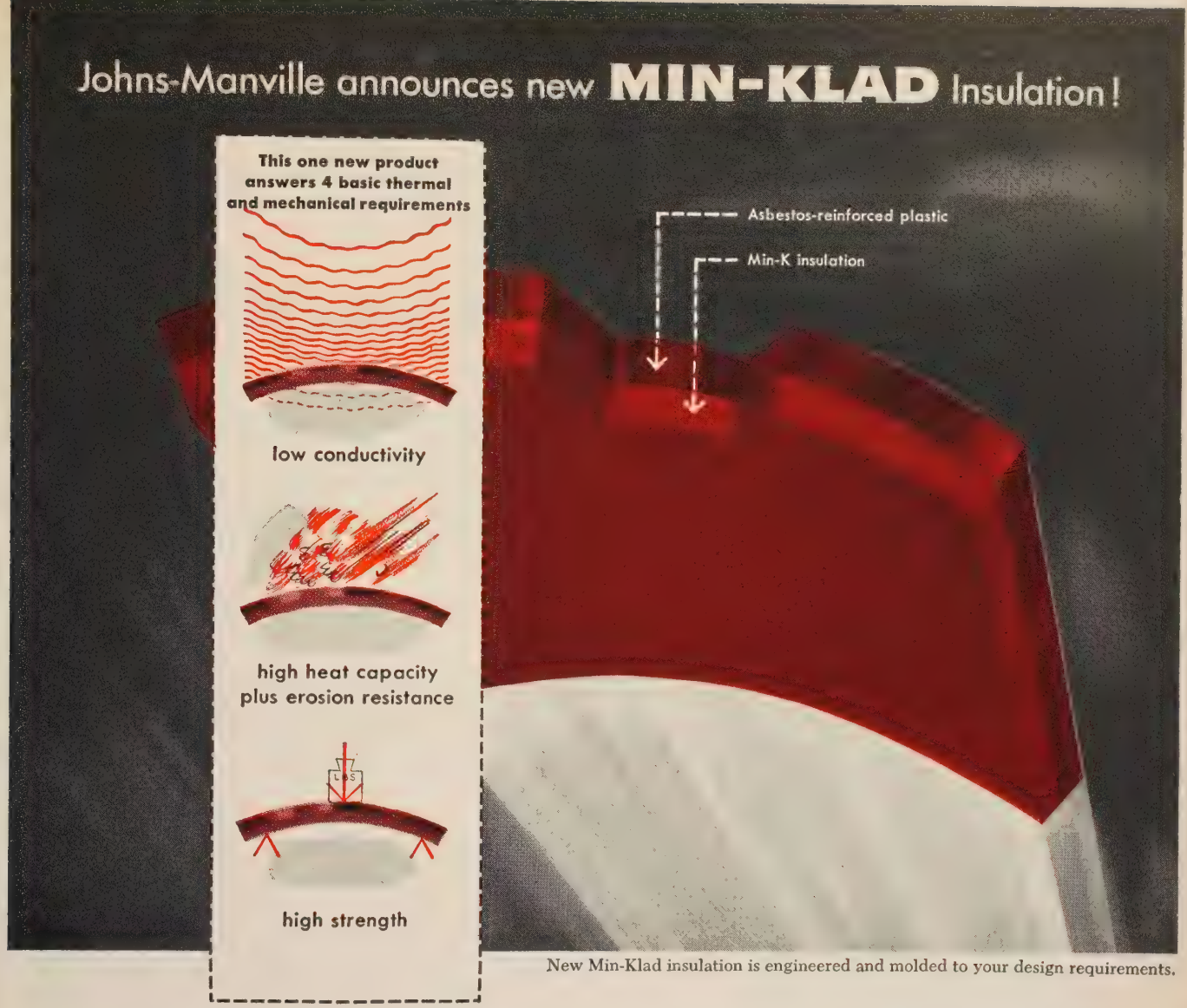
Write in No. 247 on Reader Service Card

Johns-Manville announces new **MIN-KLAD** Insulation!


This one new product answers 4 basic thermal and mechanical requirements
low conductivity
high heat capacity plus erosion resistance
high strength
Asbestos-reinforced plastic
Min-K insulation

New Min-Klad insulation is engineered and molded to your design requirements.

Combines the capabilities of asbestos-reinforced plastic with the dramatically low conductivity of MIN-K insulation!

New Min-Klad insulation may well be the most significant advance ever made in missile and rocket insulation.

Developed by Johns-Manville research scientists, Min-Klad is the only product of its kind, a permanent lamination of the missile industry's two most effective high-temperature materials: 1) reinforced plastic and 2) J-M's recently developed Min-K insulation.

Does more than plastic alone

Min-Klad gives the missile designer all the advantages of high-temperature plastic: Strength, toughness, rigidity! Erosion resistance! High heat capacity! Yet Min-Klad does more.

It also insulates . . . and with dramatic effectiveness! Its insulating element is J-M's Min-K, an insulation with thermal conductivity that is actually lower than the molecular conductivity of still air. And this conductivity (already less than half that of the best fibrous insulations) drops still further with altitude. At 10 miles, for example, it is decreased by as much as 40%, with further decreases at greater altitudes.

Wide range of applications

Min-Klad offers the missile and rocket designer a rich choice of heat-control possibilities. It may be used for a part that must insulate, yet have the structural advantages of plastic. Where requirements call for a scuff- and erosion-resistant insulating surface . . . or for a good adhesive bond between Min-K insulation and other surfaces. Or, it may be used to control high transient temperatures! For high heat capacity of asbestos-reinforced plastic combined with the low conductivity and heat capacity of Min-K result in a product that provides minimum heat transfer under transient conditions.

Min-Klad is now being tested for approximately two dozen missile and rocket designs. Why not investigate this new material for your present thermal requirements? Upon request, we'll be pleased to send you a sample of the material along with detailed technical information. Write Johns-Manville, Box 14, New York 16, New York. (Ask, too, for information on Min-K insulation and the new aviation insulation brochure IN-185A.) In Canada: Port Credit, Ontario.

JOHNS-MANVILLE JOHNS-MANVILLE JM PRODUCTS

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NEW PROGRAM

Raytheon enters new weapons systems program and offers advancement opportunities for both Junior and Senior electronics engineers with experience in the following fields:

- Microwave engineers—component and antenna design
- Communications systems
- Guidance systems
- Computer systems
- Radar systems
- Inertial reference systems
- Feed-back control
- Auto-pilot
- Ground support
- Electronic packaging engineers
- Radar systems engineers (project management)
- Electromechanical engineer for missile control and auto-pilot design (project management)
- Mechanical engineer experienced in ground handling of large missile systems (project management)

You and your family will enjoy the many advantages of living in the metropolitan Boston area. Relocation assistance and modern benefits.

Please forward resume to:

Mr. W. F. O'Melia
Employment Manager
Raytheon Company
Bedford, Mass.

or call collect:

Crestview 4-7100
Extension 473

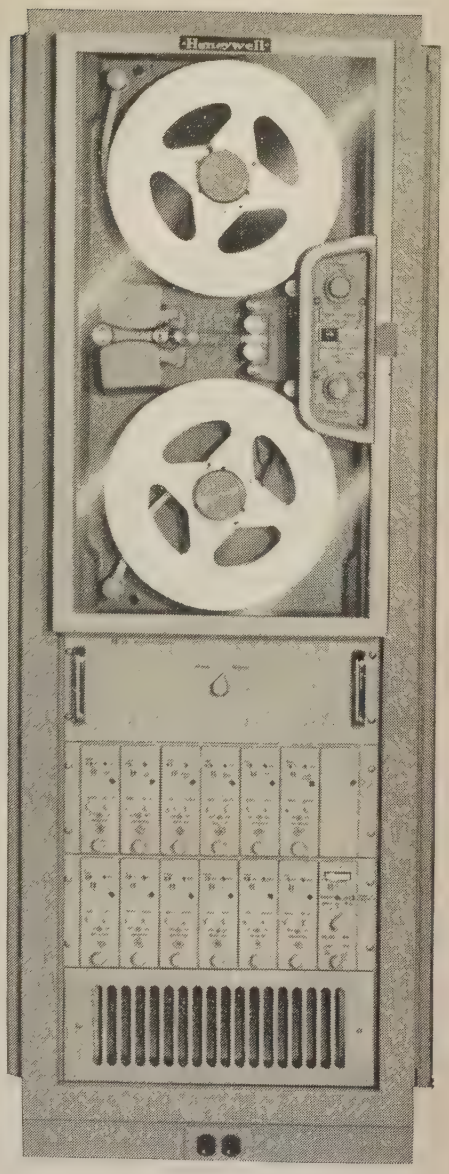
RAYTHEON MISSILE SYSTEMS DIVISION

Excellence in Electronics

Check Employment Inquiry Form on Page 183

Ionosphere, Troposphere, Everywhere

Honeywell Tape Systems win acceptance for the tough recording jobs

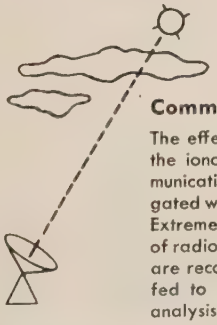


Wherever accurate collection of high speed data is required . . . from monitoring space signals and testing jet engines to studying submarine vibrations . . . Honeywell Magnetic Tape Systems are handling the jobs quickly and economically.

With Honeywell's exclusive wide tapes, these systems record as many as 40 tracks on one tape . . . preserve massive amounts of data with minimum original equipment cost. Other mechanical and electronic features insure dependable performance . . . easy operation.

For the full story on a system tailored to your needs, just give your Honeywell field engineer a call.

MINNEAPOLIS-HONEYWELL, 10721 Hanna Street, Beltsville, Md.



Communications Studies

The effect of electron clouds in the ionosphere on radio communications is being investigated with a Honeywell System. Extremely accurate recordings of radio signals from a satellite are recorded, edited and then fed to a computer for rapid analysis.

Jet Engine Testing

Stress, vibration, fuel and air pressure and critical temperatures of jet engines are all recorded simultaneously on one 1¾" tape. The Honeywell System's high capacity and unique transport switching panel make it possible to record entire test with no interruptions.

Tropospheric Studies

Tropospheric scatter propagation studies determine power spectrum amplitude distribution and median signal level with a Honeywell System. Simplified speed control makes it easy to reduce playback speed for more accurate analysis.

Honeywell

H HONEYWELL First in Control

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LOOK FOR THE DIAMONDS—SIGN OF FINISHING QUALITY

NOW—A Great New Combination for DOUBLE PROTECTION Against Corrosive Conditions on Aluminum, Magnesium or Zinc

IRIDITE®
CHROMATE CONVERSION COATINGS
and
IRILAC™
CLEAR PROTECTIVE COATINGS

Now, here's a fast, easy, economical way to almost double the protection against corrosion on your product. Simply follow up the IRIDITE process with a fast, easy application of IRILAC . . . and you've given your product extra protection for longer resistance to corrosive conditions, longer shelf or storage life, protection from handling and increased beauty for more attractive appearance and faster sales.

ON ALUMINUM

An IRIDITE-IRILAC finish will provide longer life for storm doors, windows, outdoor furniture, auto parts and accessories, tubing or wire goods. And, you have a choice of color finishes such as natural aluminum and golden yellow. Other colors may be obtained by an additional dye operation.

ON MAGNESIUM

IRILAC over an IRIDITE No. 15 finish increases corrosion protection, and provides resistance to finger printing and abrasion on all types of products, with color appearance ranging from light to dark brown.

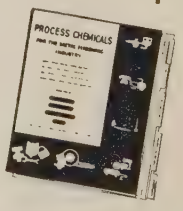
ON ZINC

IRIDITE plus IRILAC gives your product longer life and brighter appearance. Color choices range from the bright IRIDITE finish, a clear finish, through yellow iridescent to military olive drab, in addition to colored dye finishes.

IRIDITE is the tradename for a specialized line of chromate conversion coatings that can be applied to any non-ferrous metal by brush, dip or spray methods—at room temperatures—manually or with automatic equipment. Upon application, a thin film forms which becomes an integral part of the metal itself, and thus cannot chip, flake or peel. No special equipment, exhaust systems or specially trained personnel are required.

IRILAC is the tradename for a line of clear protective coatings for all metals. As safe and easy to handle as water, they may be applied by brush, dip or spray methods. No exhaust or special fire protection equipment required. Adds protection and abrasion resistance to any base metal, plated part or parts treated with electrolytic or chemical post treatments, without chemical change.

For complete technical information on IRIDITE Chromate Conversion Coatings or IRILAC Clear Protective Coatings, write for FREE TECHNICAL MANUAL. Or, see the Allied Field Engineer in your area. He's listed under "Plating Supplies" in the yellow pages.



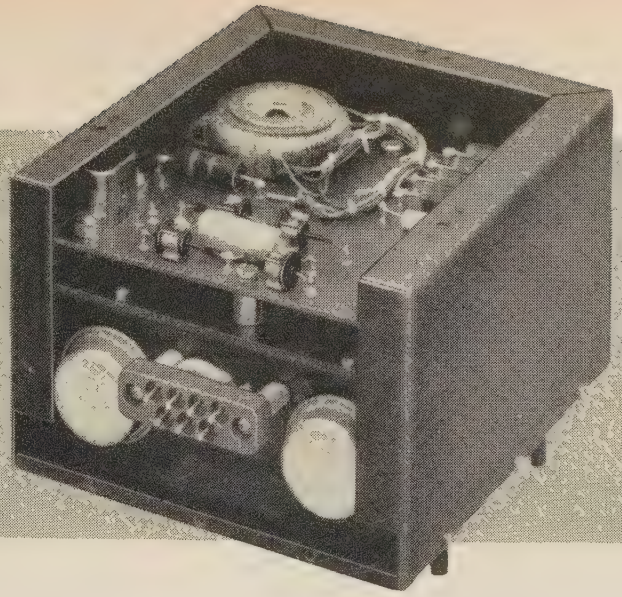
Allied Research Products, Inc.

4004-06 EAST MONUMENT STREET • BALTIMORE 5, MARYLAND
BRANCH PLANT: 400 MIDLAND AVENUE • DETROIT 3, MICHIGAN
West Coast Licensee for Process Chemicals: L. H. Butcher Co.

Chemical and Electrochemical Processes, Anodes, Rectifiers Equipment, and Supplies for Metal Finishing

IRIDITE® Chromate Coatings	IRILAC™ Clear Coatings	ISOBRITE® Plating Brighteners	ARP® Chemicals & Supplies	WAGNER Line of Equipment

Write in No. 251 on Reader Service Card at start of Product Preview Section



AMSTAT* Wider in RANGE

AMSTAT* Broader in SCOPE

*AMSTAT—*American Electronics' new line of Static Power Devices*

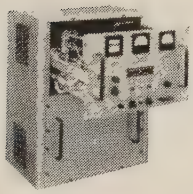
WIDER IN RANGE—*offering units with the widest rating range available in the industry—10VA to 3000 VA—50C to 6KC—single and three phase.*

BROADER IN SCOPE—*opening new applications for the desirable features of static power devices with a complete line of Inverters, Frequency Changers and Converters in Transistor and Silicon Controlled Rectifier units.*

American Electronics, Inc., through its Electric Machinery and Equipment Division, now offers one dependable source for a complete line of solid-state power converting devices. Their outstanding performance characteristics are unique in the industry, including operation to zero load... operation with leading and lagging power factor loads and with highly unbalanced loads.

Advanced design features such as spike suppression, inherent short-circuit proof circuitry, and greater tolerances to heat, assure longer unit life and unmatched reliability.

Only part of the AMSTAT story can be told in this limited space. For complete information on American Electronics' new line of Static Power Devices, please write:



Model 8254VR Silicon Controlled Rectifier Frequency Changer for Laboratory Use.

AMERICAN ELECTRONICS, INC.

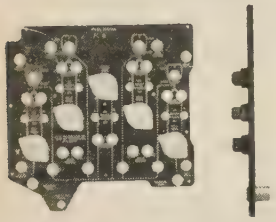
ELECTRIC MACHINERY & EQUIPMENT DIVISION

2112 NORTH CHICO AVENUE, EL MONTE, CALIFORNIA • CUMBERLAND 3-7151

MODEL NO.	DESCRIPTION	OUTPUT			INPUT VOLTAGE		MAX. AMBIENT TEMP. (Operating)	REMARKS
		VA	VOLTS	Freq CPS	Nom.	Range		
8251VT	Inverter, 1 ph	100	115 V	400	28 VDC	26-29 VDC	—54°C to 71°C	Square wave output. Frequency and voltage unregulated.
8252VT	Converter, 1 ph	100	6.3 VAC, 6 amps 400 VDC, 75 ma 150 VDC, 120 ma	1200 DC DC	28 VDC	25-31 VDC	—54°C to 71°C	Regulated and filtered DC outputs.
8253VT	Inverter, 1 ph	100	117 V	400	28 VDC	26-31 VDC	—54°C to 71°C	Sine wave output. Frequency and voltage regulated.
8254VR	Frequency Changer, 1 ph	500	105-125 V adj.	360 to 440 adj.	115 VAC	105-125 VAC	40°C	Sine wave output. Frequency and voltage regulated. Silicon controlled rectifier unit.
8255VT	Inverter, 3 ph	200	115/200 V	400	28 VDC	26-29 VDC	—54°C to 71°C	Stepped voltage wave output. Frequency regulated. Voltage not regulated.
8256V	Filter Pack, 3 ph	200	115/200 V	400	28 VDC	26-29 VDC	—54°C to 71°C	Sine wave output. Frequency, but not voltage regulated.
8257V	Regulator Pack, 3 ph	100	115/200 V	400	28 VDC	26-29 VDC	—54°C to 71°C	Frequency and voltage regulated.
8258VR	Inverter, 1 ph	500	115 V	400	28 VDC	26-29 VDC	65°C-500VA 85°C-300VA	Sine wave output. Voltage and frequency regulated. Silicon controlled rectifier unit.
8259VR	Inverter, 3 ph	1500	115/200 V	400	28 VDC	26-29 VDC	65°C-1500VA 85°C-1000VA	Sine wave output. Voltage and frequency regulated. Silicon controlled rectifier unit.
8260VR	Inverter, 3 ph	1000	115/200 V	400	28 VDC	26-29 VDC	85°C Max. MS 33543 Curve I	Sine wave output. Voltage and frequency regulated. Silicon controlled rectifier unit. Class H insulated magnetic components.
8261VR	Frequency Changer, 3 ph	3000	115/200 V	400	117 VAC	105-125 V 320 to 480 cps	65°C-3000VA 85°C-2000VA	Sine wave output. Voltage and frequency regulated. Silicon controlled rectifier unit.

Write in No. 252 on Reader Service Card at start of Product Preview Section

PRODUCT DIGEST from U. S. RADIUM



EDGE-LIGHTED PANELS

Special-purpose panels and dials accurate to MIL spec are available from United States Radium Corporation. Standard edge-lighted and integral edge-lighted products by Lackon® provide optimum legibility and contrast, with high resistance to humidity, surface abrasion. **Request Bulletin 103**

DIALS, PANELS AND NAMEPLATES

Metal dials and panels include a greater variety of finishes, colors and processes than ever before. **Request Bulletin 104**

New lithographed nameplates and panels featuring special hard, abrasion-resistant finish are available with or without adhesive backing in various thicknesses.

CATHODE-RAY TUBE PHOSPHORS

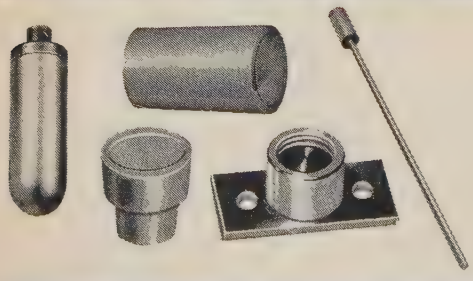
USR offers a variety of phosphors for TV and industrial cathode-ray tube applications. **Request Bulletin 105**

RADIATION SOURCES FOR ELECTRON TUBE IONIZATION

Specially-fabricated isotope sources—Ni^{63} plated electrodes and radium foil—are now being produced as ionization sources for electron tubes.

ISOLITE LIGHT SOURCES

New 360° light source and high-brightness one-way lamps use luminescent bulbs energized by Kr^{85} gas. Units visible at 500-2000 ft., depending on model, size, color; service life to 10 years. New Isolite markers, signs and placards now available. **Request Bulletin 106**



RADIATION SOURCES

Sealed beta, gamma and neutron sources for research, gauging, radiography and related applications are available with varying intensities and energies. **Request Bulletins 107, 108, 109.**

UNITED STATES RADIUM CORPORATION

MORRISTOWN, N. J. | Offices: Chicago, Illinois and North Hollywood, Calif. Subsidiaries: Radelin Ltd., Port Credit, Ont., Canada and U. S. Radium Corp. (Europe), Geneva, Switzerland.

DATA PREVIEW

ENVIRONMENTAL CHAMBERS — A new six-page brochure is available from **Conrad, Inc., Dept. S/A, 141 Jefferson St., Holland, Mich.,** showing its walk-in environmental chambers for temperature, altitude, and humidity. Also described are its missile test facilities and components testing units.

Write in No. 468 on Reader Service Card

MULTI-CHANNEL TELEMETERING—Catalog #900 describes the complete line of multi-channel equipment for radio and wired telemetry manufactured by **General Devices, Inc., Dept. S/A, P.O. Box 253, Princeton, N.J.** In addition, engineering specifications and information in other forms relative to equipment and services is available on request.

Write in No. 469 on Reader Service Card

GUIDED MISSILE SYSTEMS—The facilities, services, and personnel of **Washington Technological Associates, Inc., Dept. S/A, 979 Rollins Ave., Rockville, Maryland,** are described in an illustrated brochure they have issued recently.

Write in No. 470 on Reader Service Card

PM MOTOR—Catalog Bulletin X-112 contains information on the newly developed permanent magnet motor with greater output capabilities than the smaller PM motors, says **Globe Industries, Inc., Dept. S/A, 1784 Stanley Ave., Dayton 4, Ohio.**

Write in No. 471 on Reader Service Card

FILTERS—A 16-page catalog describing the complete line of standard production Mechanical Filters has been issued by **Collins Radio Co., Western Div., Dept. S/A, 2700 W. Olive Ave, Burbank, Calif.**

Write in No. 472 on Reader Service Card

FLEXIBLE HOSE—A six-page, illustrated bulletin on its new 400 finger flexible teflon hose for industrial and aircraft applications is available from **Titeflex, Inc., Dept. S/A, Springfield, Mass.** Construction and assembly are discussed as well as its flexibility and availability. Specifications and ordering information are included.

Write in No. 473 on Reader Service Card

SWITCHING TRANSISTORS — A 4-page data brochure describing their Type 2N501 Germanium Super High-Speed Switching Transistor is available from **Sprague Electric Co., Dept. S/A, North Adams, Mass.** This micro-alloy diffused-base transistor is said to be the fastest mass-produced switching transistor available today and is unexcelled for computer applications.

Write in No. 474 on Reader Service Card

more on page 326

On the Ground as in the Air . . .

RELIABILITY rides on BEARINGS

Whatever the weapons system, the reliability of ground support equipment rides on bearings. Many such bearings have solid cylindrical rollers.

Reliability statistics prove that where load-ability or life expectancy are vital . . . and both space and weight are limiting factors . . . roller bearings do a better job over a longer period.

Rollway's long experience in roller bearings for military and commercial equipment is reflected in our new *Air-Rol* Data Book. It contains new and vital criteria for bearing selection. A letter on company stationery will bring it to any qualified person by return mail. Rollway Bearing Company, Syracuse, N. Y.

ROLLWAY®

Air-Rol® **BEARINGS**

COMPLETE LINE OF RADIAL AND THRUST CYLINDRICAL ROLLER BEARINGS

ENGINEERING OFFICES: Syracuse • Boston • Chicago • Detroit • Toronto • Pittsburgh • Cleveland • Seattle • Houston • Philadelphia • LosAngeles • SanFrancisco

Write in No. 254 on Reader Service Card at start of Product Preview Section

The True Test of Capability

Not too long ago an editorial roundup on inertial guidance and navigation had an interesting quote: "An inertial guidance system is like a baby. It's easy to conceive, but difficult to deliver."

The truth of this observation may have been lost in the midst of claims and counter-claims that have characterized the field since inertial guidance was accepted as feasible in 1949. But these claims have not altered the fact that *delivery of a reliable inertial system remains the true test of capability.*

Sperry's first claim is that it isn't easy.

In 1950 we undertook the most difficult technical inertial challenge—to provide inertial navigation of extreme accuracy, over many hours of operation, under most adverse environmental conditions and capable of operating reliably again and again over a period of years.

Today, flight tests indicate that the Sperry Doppler inertial bombing-navigation system for Convair's B-58 supersonic bomber is the most advanced and proven airborne inertial system. As a measure of the task, there have been 25 million man-hours employed to develop and produce this successful inertial guidance. But, as a result, the nation has in the B-58 Hustler the most thoroughly studied, analyzed, tested, evaluated and *understood* inertial guidance system in being.

It is this *understanding* of things inertial that the Sperry team of scientists, engineers and production specialists can bring to the *delivery* of new inertial advancements for manned aircraft, space vehicles and for missiles and rockets. The B-58 bombing-navigation system is a development and product of Sperry's Air Armament Division, Sperry Gyroscope Company, Division of Sperry Rand Corporation, Great Neck, New York.

Engineers: A career with Sperry provides engineering's highest challenges and most satisfying rewards. Write to R. F. Garbarini outlining your background and interests.

SPERRY

Write in No. 255 on Reader Service Card at start of Product Preview Section

Checking Regulus I surface-to-surface missile prior to launching from experimental cart. For the use of Ni-Cr-Mo steel castings in the launching cart, Chance Vought was judged a National Award Winner in the Third Product Development Contest conducted by the Steel Founders' Society of America.

How castings of 4330 nickel-alloyed steel help boost a missile up, push assembly cost down

20-Ni-Cr-Mo steel castings replace 73 detail parts, eliminate 300 hardware items in new launching cart

Regulus I, made by Chance Vought, is normally boosted skyward from a rail launcher. The Navy, however, wanted a more economical launching technique that would utilize a carrier's powerful catapults . . . that would also simplify handling of the missile aboard ship.

The answer was the expendable catapult cart you see above.

The carts, also made by Chance Vought, are assembled with 20 cast 4330 steel cluster joints welded to tubing of the same material. These castings replaced 73 detail parts required in the plate-type fittings of the experimental units used to prove the idea. They also eliminated 300 hardware items, such as nuts and bolts. Assembly is easier, and far more economical.

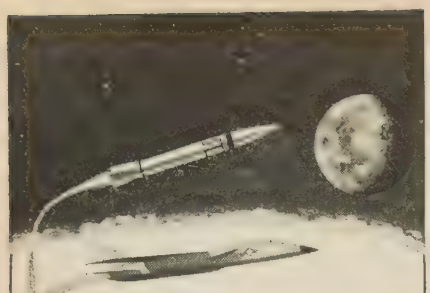
Why Ni-Cr-Mo steel for the castings? The 4330 composition of 1.8% Ni .65% Cr. .25% Mo heat treated to 125,000 and 150,000 psi gives these castings the combination of high strength and great toughness needed to stand up to the tremendous shock of take off.

What about your product? Can it use the economy, high strength, and shock resistance offered by Ni-Cr-Mo steel castings? You can get complete information by writing:

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street INCO New York 5, N. Y.

INCO NICKEL

NICKEL MAKES ALLOYS PERFORM BETTER LONGER

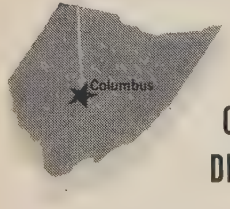


DYNAMICS ENGINEERS

Here is your opportunity to join the Dynamics Section of the Columbus Division. Established only a few years ago, this Section is widely acknowledged as a leader in the development of Dynamic Science.

Major areas of activity are: 1. Aeroelasticity: structural stiffness analysis, flutter-vibration, environmental vibration, static aeroelasticity and acoustics. 2. Flight Loads: maneuvering, gust, blast, buffet and landing loads; design load criteria, static and dynamic load analysis, and flight load measurements. 3. Flight Dynamics: analysis of dynamic systems including structures, missiles, aero-mechanical systems, crew escape systems, etc., utilizing precision analog computing equipment. 4. Dynamic Development: advanced design support, research contracts, specialized research in general field of dynamics. 5. Dynamics Testing: ground vibration testing, acoustic testing, aeroelastic model design and testing, flight vibration and flutter testing.

For details, write to:
H. Keever
Engineering Personnel Manager, Box SA 9-491
North American Aviation, Inc.
Columbus, Ohio.



THE COLUMBUS DIVISION OF

NORTH AMERICAN AVIATION, INC.

Home of the T2J Buckeye and the A3J Vigilante

DATA PREVIEW

SYNCHRONOUS MOTORS—A revised edition of Catalog E1-4 on its synchronous motors has been published by **Electric Indicator Co., Inc., Dept. S/A, Camp Ave., Stamford, Conn.** Quick reference tables provide specifications on the electrical, physical and performance characteristics available for each motor type

Write in No. 475 on Reader Service Card

RUBBER COMPONENTS—A two-color, eight-page brochure, in file folder form, describing its facilities for producing custom-made rubber parts, seals and components, has been issued by **Goshen Rubber Co., Inc., Dept. S/A, Goshen, Indiana.** Products, services, and personnel are highlights of this illustrated publication.

Write in No. 476 on Reader Service Card

WAVEGUIDES—A 4-page bulletin describing products ranging from simple sections of straight wave-guide through plane-turners and transitions, such wave-guide equipment as simulated loads, slide slug tuners and slotted lines is available from **I-T-E Circuit Breaker Co., Dept. S/A, 1900 Hamilton St., Philadelphia 30, Pa.**

Write in No. 477 on Reader Service Card

DIGITAL SUBSYSTEMS – An 8-page facilities brochure containing information on the products, facilities and personnel is available from **Tempo Instrument Inc., Dept. S/A, P.O. Box 388, Hicksville, N.Y.** Described also are the transistorized logic elements developed and applied by the company.

Write in No. 478 on Reader Service Card

TRANSISTORS—A 6-page bulletin describing their silicon unijunction transistors is avalable from the **General Electric Co., Semiconductor Products, Dept. S/A, Electronics Park Syracuse 1, N.Y.** Specifications on types 2N489 through 2N494 are also detailed.

Write in No. 479 on Reader Service Card

THERMOSTAT—Technical Data Bulletin MIL-THSN-13 describes the new M201 thermostat designed for precision applications, made by **Metals & Controls Corp., Dept. S/A, Attleboro, Mass.** Ratings and applications are included.

Write in No. 480 on Reader Service Card

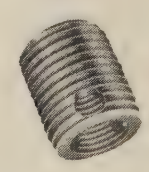
ROTATION JOINT—Bulletin A-4 describes its rotation joints, designed for airborne use. These joints are said to be lightweight, corrosion resistant, and have had leakage rates actually less than demanded by specifications. This brochure is available from **Marman Div., Aeroquip Corp., Dept. S/A, 11214 Exposition Blvd., Los Angeles 64, Calif.**

Write in No. 481 on Reader Service Card

The quickest most practical way to put strong threads in soft materials the TAP-LOK® INSERT

SLOTTED

IN SOFTER METALS AND PLASTICS...Has full V-form external threads to provide maximum locking torque and permit wide choice of mating hole sizes. Recommended for soft aluminum, zinc die castings, sand castings and plastics. Meets requirements of MIL-MS-35914.



H-SERIES

FOR HIGHER STRENGTH MATERIALS...Has heavy wall and truncated root external thread and three-hole cutting edges for hard-to-tap higher-strength materials and to meet MIL and other specs calling for Class 3B thread fit for gaging after installation.

P-SERIES

FOR SPARK PLUG SOCKETS ...Designed to eliminate thread wear and renew damaged threads in spark plug sockets in aluminum cylinder heads. Available from stock for standard plug sizes to meet most common needs.

W-SERIES

FOR WOOD...Has coarse pitch external threads offering maximum strength in combination with ability to be driven into thin sections without splitting them. For furniture, cabinets and other wooden parts where strong, permanent threads are needed, or that are frequently assembled and disassembled.

Another fastener development from—

TAP-LOK GROOV-PIN CORPORATION

1121 Hendricks Causeway, Ridgefield, N. J.

Write in No. 257 on Reader Service Card

Check Employment Inquiry Form on Page 183

IDVAC SUPER ALLOYS

OLVING MODERN DESIGN SPECIFICATIONS

Parts for Missiles—Rockets—Jet Engines are constantly calling for newer alloys to operate at higher temperatures. Alloys made by the Midvac process of consumable electrode melting are currently answering these needs and new ones are being developed in anticipation of more critical operations.

Midvac Alloys insure increased tensile and impact properties, improved stress rupture strength at elevated temperature, and longer fatigue life.

Standard commercial alloys can also be made with increased cleanliness resulting in higher properties than have been available under conventional means.

Offered in ingots, billets or forgings for the production of missile combustion chambers, tail cone assemblies, jet engine parts, aircraft landing gear components or any other parts requiring properties beyond the capabilities of conventional steels.

MidVac Steels

MIDVALE-HEPPENSTALL CO., NICETOWN, PHILADELPHIA 40, PA.

Subsidiary of HEPPENSTALL COMPANY, Pittsburgh, Pa.

Write in No. 258 on Reader Service Card at start of Product Preview Section

Reaching for the Moon, Mr Designer?

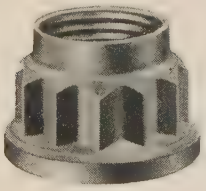
Here's a tip... Millions of Kaylock® nuts ago, a new aircraft fastener made its bow... the Kaylock H20, first lightweight, high tensile, all-metal, self-locking nut.

Its significant improvement over then-existing fasteners – lighter weight, greater strength, smaller envelope – won immediate acceptance by airframe weight engineers and designers.

Today, with a premium on weight and space savings in aero-space vehicles and engines, design engineers depend more than ever on Kaylock nuts. So here's a tip...

If you're reaching for the moon, Mr. Designer, reach for your up-to-the-minute Kaylock catalogs first. Chances are, *your* "brainchild" will *get there sooner.*

Fastener with a past – that's the Kaylock H20. A favorite callout of design engineers for the past 3 years, the H20 was the first high tensile, all-metal nut using the elliptical self-locking principle for which Kaylock nuts are famous. "Vital statistics" include:



Service Temperature: 550°F
Tensile Strength: 180,000PSI
Material: Alloy Steel

Ready to Help – Here are a few of the Kaylock external wrenching nuts built to meet rigid requirements in weight and space reduction.

H14
Service Temperature: 550°F
Tensile Strength: 160,000PSI
Material: Carbon Steel

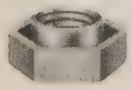
H23
Service Temperature: 550°F
Tensile Strength: 180,000PSI
Material: Alloy Steel

H24
Service Temperature: 550°F
Tensile Strength: 220,000PSI
Material: Alloy Steel

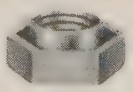
H41
Service Temperature: 900°F
Tensile Strength: 125,000PSI
Material: A286 CRES

H33
Service Temperature: 1200°F
Tensile Strength: 160,000PSI
Material: A286 CRES

H19083
Service Temperature: 1400°F
Tensile Strength: 160,000PSI
Material: M252 CRES



H10
Service Temperature: 550°F
Tensile Strength: 125,000PSI
Material: Carbon Steel



H31
Service Temperature: 900°F
Tensile Strength: 125,000PSI
Material: A286 CRES

Kaylock
ALL METAL SELF-LOCKING NUTS

TRADE MARK

KAYNAR MFG. CO., INC.– KAYLOCK DIVISION • *World's largest and oldest manufacturer of lightweight, all-metal, self-locki*
Home office and plant: Write Box 2001, Terminal Annex, Los Angeles 54, California
Branch offices, warehouses and representatives in Wichita, Kansas; New York, N. Y.; Atlanta, Georgia. Canadian Distributor: Abercorn Aero, Ltd., Montreal.

Write in No. 259 on Reader Service Card at start of Product Preview Section

Metric system's part in exports

After following with great interest your editorials and readers' mail regarding the change-over to the metric system, I feel compelled to add a foreigner's view on the subject. As I am working in the electronic field, and especially with electronic components, I feel qualified to express what many designers in this country think.

The Swedish electronic industry relies to a great extent on import of high quality components, most of which come from the UK and USA. The German, French, Italian, Swiss, and Japanese industries are however on the way up, and when there are two or more equally good components, the one with data given in the metric system will be the choice. This shows that the metric system also plays an important part in export sales.

Here are a few examples to illustrate my views:

- Threaded components, such as capacitors and stand-off terminals, must be supplied with nuts, thus increasing weight and price (in previous dollars), and a lost nut is very difficult to replace.
- Dimensions given like "No. 4 drill", "4B.A. thread", "psi", have lost many customers to the American manufacturers. Conversion tables for such measurements are not readily available at many firms.
- A clipping from a resistor catalog: ". . . rated for hot spot temperature of 515 *deg F* in an ambient temperature of 40 *deg C* . . . dim. 19/32x .500" . . . leads 18 AWG." To work this out, four different conversion tables are required.

Hoping that my letter will add fuel to this most important and interesting discussion.

Saab Aircraft Co. — Bengt Hedrén
Gothenburg 5, Sweden — Avionics Laboratory

With great attention, I read your regular articles on the metric system, and I know that a few of my colleagues also are impressed by the discussions.

I have almost 15 years' practical experience with the inch system and somewhat more in purely metric industry. Therefore, I can claim to know exactly the pro and con of both sides.

Some of the following points have been taken up in later issues of SPACE/AERONAUTICS, since I made notes for this letter. Hoping that any response is welcome to you and supporting the cause, I will send it now.

- The world is metric already.
- Our foreign trade will suffer, if we do not convert.
- The conversion is not so difficult as many think.
- We can at the same time improve standardization.

We must face the unpleasant fact that we are backward. The world is metric now. British engineers in publications of world-wide interest give figures both in inches and according to the metric system. The writer guesses that 70 per cent of the world's production in machinery, and a higher percentage in electric, electronic, and laboratory equipment, is metric at present. It is recommended that these figures be investigated more exactly. Let us throw away this burdensome heritage from old times of isolation.

The U.S. industry has lost millions of dollars' worth of contracts because we could not deliver pipes fitting to international dimensions. I think of pipe lines in the Middle East.

Countries that converted to the metric system had set a changeover period of 30 years, for instance 1860-1900. This time turned out to be unnecessarily long. Considering our present, much greater pace of progress and faster turnover of tools, a period of 20 years will suffice to make the move almost completely. Only in a few fields an extension may be necessary. Experience has been that steel mills did not use up their expensive equipment and had to prematurely discard inch-rollers, in order to manufacture metric profiles. Those countries extended the transition period for, say, two-inch profiles, selling them as 51-mm profiles, until all material was rolled out with the dimension 50 mm.

Metric standards are well established, exactly defined, and have proven their value a very long time already (50 years). They are developed to the right point, are feasible—no over-standardization has sneaked in, there is no lack of necessary standardization, as with the inch-countries. The metric standards can be taken over as they are; even most symbols are free from any tie to a certain language. There is no doubt in the writer's mind that Russia's industrial progress during the past 40 years was decisively supported by the introduction of the metric system.

Lycoming Div. — Dr. Fredrich K. Bielitz
Avco Corp. — Chief, Mechanics & Dynamics Dept.
Stratford, Conn.

Most Important Deterrent to Metric System

Speaking as one associated with an international division of a U.S. producer, my problems involve the use of both British and metric systems of measurement. When we started a plant in Germany a few years ago, we attempted to translate all our drawings into the metric system in order to utilize the standard machine tool calibrations which exist and also to utilize a system with which the production personnel was familiar.

Because of the vast amount of effort required to redraw all drawings, we have since abandoned this program, and this entire factory is now working to U.S. drawings. The satisfaction which resulted from this action would certainly indicate that amongst professional personnel any reluctance to change systems must be charged to something other than the inability to make the change.

In the fields of design and production, I think, will be found the biggest objections to the conversion to the metric system. Certainly, in scientific areas this problem is quite simple.

While my sympathies are entirely with the metric system, from a very practical point of view, it must be recognized that—even in the metric system countries—there is no uniformity regarding the use of metric screw threads.

For example, in Germany we have a magnificent set of standards established in the *Deutsche Industrie Normen* standards. These standards contain metric screw threads. However, in Germany, British Whitworth threads are used probably more than metric threads. The Ermeto Company, a manufacturer of hydraulic tube fittings, for example, lists in their catalog fittings for both metric and British Whitworth parts.

In some respects, it would be a very fine achievement if the U.S. were to swing over to the metric system and to

more on next page

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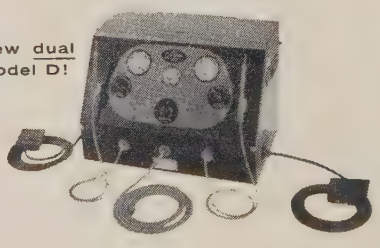

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utilize metric screw threads entirely. This would virtually force other countries—with the possible exception of Britain—into the same camp in very short order.

This, however, is an idealistic approach, and one which I do not think will be taken until such time as the industrial capacity of the rest of the world rises to a point where the U.S. must conform with the standards which exist in foreign countries in order to sell our products.

It is regrettable that the switch to the metric system was not made back in the mid-Thirties. If we look at the tremendous amount of scientific and engineering work that has been done since that time, as well as the increase and development of world markets for all products, it is quite regrettable that this did not happen.

Henry C. Parsons
Engineering Manager
International Div.
Vickers, Inc.
Detroit 32, Mich.

Up to Public and Industry

The fact that you have started a survey on the merits and advisability of converting to the metric system in America is most gratifying; this is a very important question.

I should like to suggest, however, that the question is not up to the scientists or the engineers, for most of them are already convinced, but should rather be referred to the public and to the industry.

The advantages of a system of measures in which the units of volume and mass are all correlated through a common unit of length in the decimal system need not be emphasized at this time. Obviously, this system is more logical and more rapid than those in which the various units are not based on a common origin and are not subdivided or multiplied according to the decimal scale.

However, let's remember it took the fanatical drive of the French revolutionaries to put it over as part of a general "start from scratch" policy with all the turmoils that followed. Furthermore, this was before the industrial revolution and there were relatively few tools to convert.

Scientists who deal with concepts rather than exact dimensions think and communicate in terms of fundamentals the world over and are capable quickly to convert to any system of measures if necessary. It would seem that this is becoming so for most high level engineers; furthermore, modern electronic calculators can perform conversions as part of computational programs with no substantial increase in time or cost, and no less in accuracy.

This would suggest that the scien-

more on page 332

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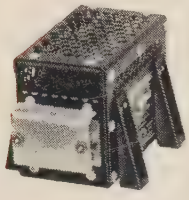
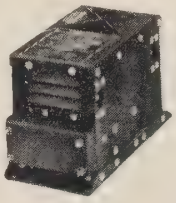
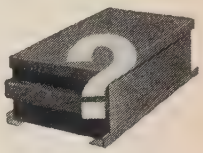


20-Amp Silicon T/R used on Chance-Vought F-8-U and Douglas A4D-2N



Launcher power supply for Lockheed's F-104 Starfighter



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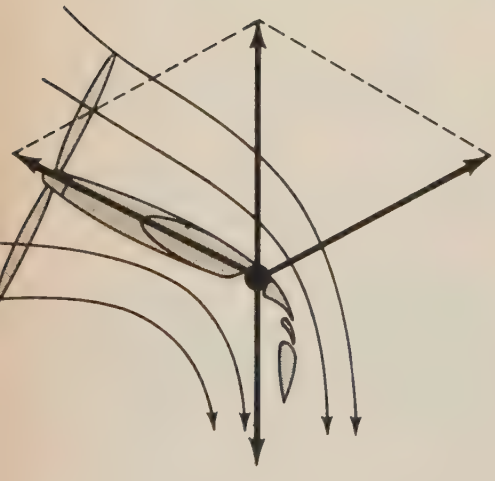
The modern successor to faithful predecessors

BREGUET 941

STOL transport aircraft



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tific and the R&D world, although strongly opinionated, does not care enough to provide the necessary drive to sell the public, and hence the Government and the industry at large, on such a costly and momentous change. The areas where the necessary drive and justification may be found . . . elsewhere.

I should like to suggest that the time is ripe for the change and that there are sufficiently strong arguments in the public domain and in the industry to initiate immediately, and at the proper rate, conversion to the metric system in America.

As universally recognized, the metric system is logically devised, and for this reason is much easier to teach and remember. Therefore, it is at the grammar school level that we should start.

Having learned it myself in France, I always use it for quick mental calculations just because it is easier that way. In fact, it is not the scientist or the engineer who will benefit most; it is the public at large, by being capable of more rapid and more accurate everyday calculations or mental estimates.

Obviously, the question becomes quite irrelevant, when an electronic calculator is used! But for the pupil and the layman, it is certainly easier to grasp and remember that a liter (which is 0.1^3) of water (or wine!) weighs one kilogram; that his car weighs two tons, or the same as 200 liters of water (at four degrees C to be exact, but that's not the point!) that his property which is 20x30 m is 600 m^2 or 600 ares or 0.0600 hectares, etc. Just try to take yourself through that exercise in the English system without a handbook!

So let's start at the grammar school level, and public opinion will in a matter of a few years be on the side of the metric system (and of the scientist). Thus, the public will have a better understanding of the dimensions of its surroundings and will be better equipped to increase its knowledge having a better tool to do it with.

From the viewpoint of communications with the outside world, it is almost self-evident that we should use the same system as most other nations. Let's remember that newly independent nations are going to use the metric system and the sphere of influence of the U.S. becomes an important factor in this question. . .

Marcel Pir
Westbury, N.Y.

How to Avoid Conversions in Gas-Law Problems

Everyone will admit that errors may creep in on conversions from metric to English units in proportion to th

more on page 33

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number of factors introduced into the system.

In gas-law problems, let's eliminate the conversions completely. Avogadro's Law is used so much in gas problems; remember, it states that "22.4 liters of any gas will weigh its molecular weight expressed in grams; e.g., 22.4 liters of O_2 equals 16x2 = 32 gm, and one liter of O_2 weighs 32/22.4 gm.

This is not too difficult so far, but it becomes more cumbersome when, instead of trying to find out the weight of one liter of gas in grams, you now need to know the weight of one cu ft of gas, either in ounces or pounds. Many conversions are required and errors easily creep into the calculations.

However, there is a simple way to calculate standard gas densities in English units without any conversion factors at all. All you need to know are the atomic weights, which are usually memorized with use anyway.

It is a mathematical coincidence that the ratio of one liter to one cu ft equals the numerical ratio of one gram to one ounce. (Proof: Let's change the cubic foot to liters and ounces to grams, and you have 1/28.3153 liters equals 1/28.3495 gm. Finding the quotients on each side of the equation you have 0.035316=0.035274, and the difference equals 0.000042 and, (0.000042/100)/0.35316=0.1189 per cent error.)

Therefore, in the preceding problem, if English units are desired, you can state that 22.4 cu ft of any gas will weigh its molecular weight expressed in ounces; e.g., 22.4 cu ft of O_2 equals 16x2=32 oz, and then one cu ft of O_2 weighs 32/2.4 oz right off. Notice that no metric to English conversion factors are used in the calculation.

Back in 1947, one of my post graduate instructors in the university thought I had cheated on an examination because I had the right answer but did not use the extensive conversion and accompanying calculations that everyone else had used that day. Furthermore, I was finished in record time and my solution was correct with one tenth of one per cent.

The instructor hadn't heard of this simple short cut. It is not new, but you would be surprised how few people know about it.

Perhaps there are some other simple English-metric relationships which could be publicized for engineers' general use. Nomographs are very useful. Although they are accurate, it is difficult to read them to, say, several decimal places, when it is necessary.

Lt. Col. Clifford F. L. Mohr, USAF
Assisant to the Chief
Materials Laboratory
Directorate of Laboratories
Wright-Patterson AFB, Ohio

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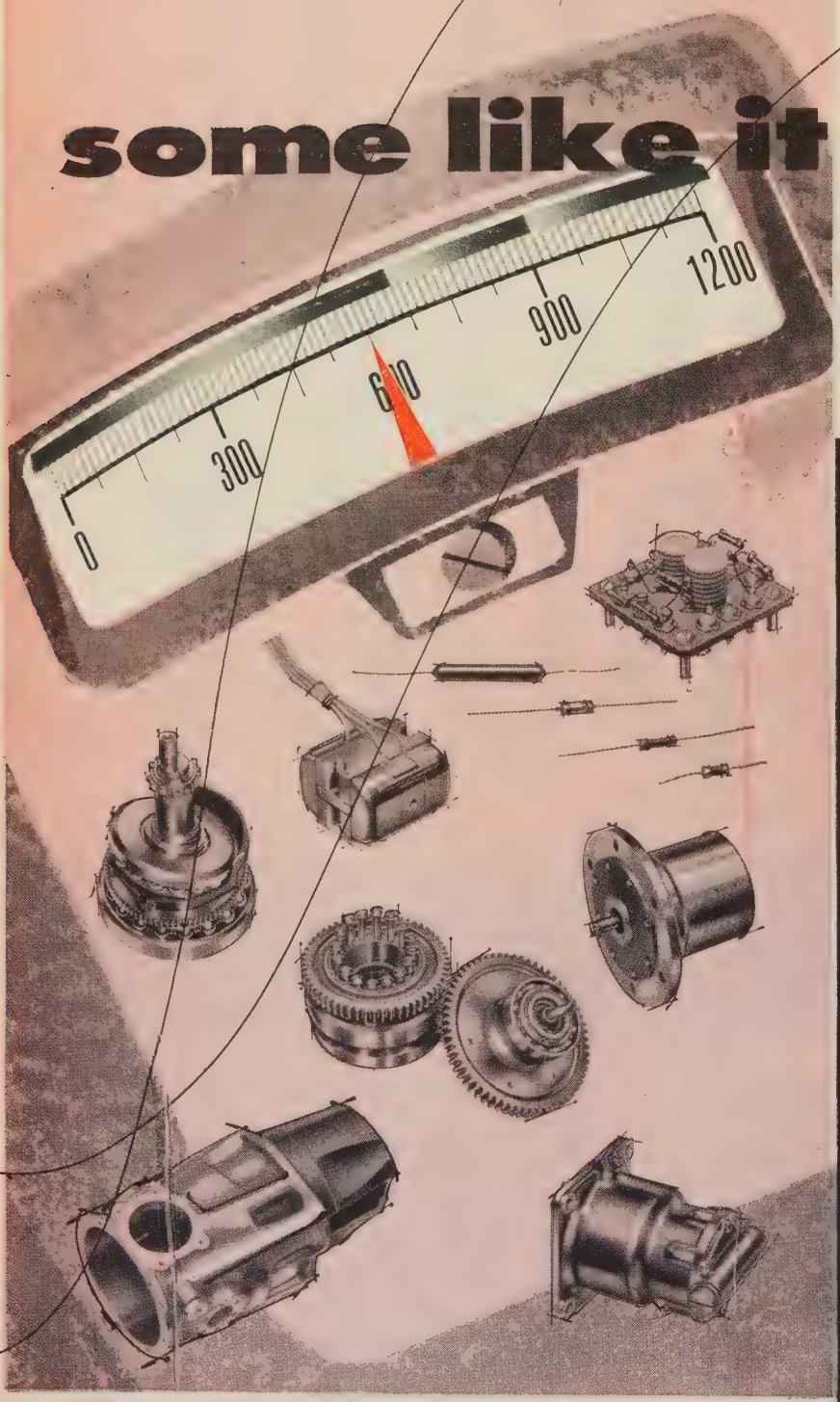

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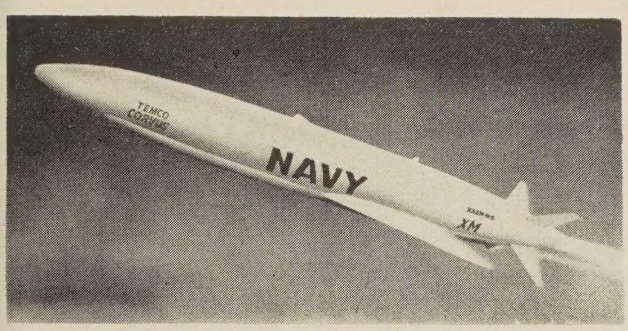
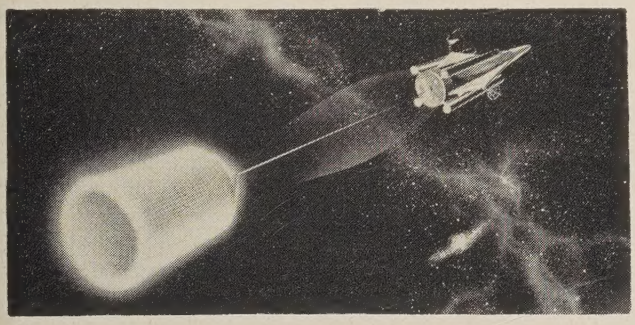
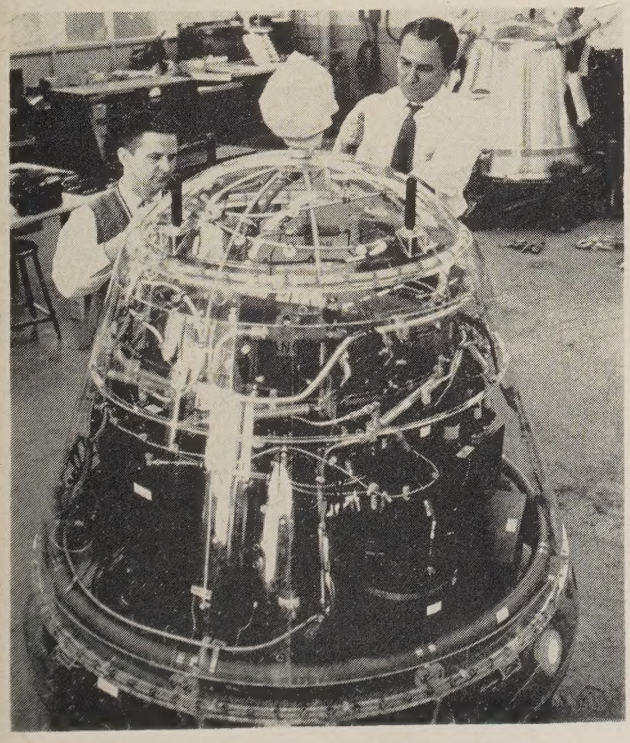
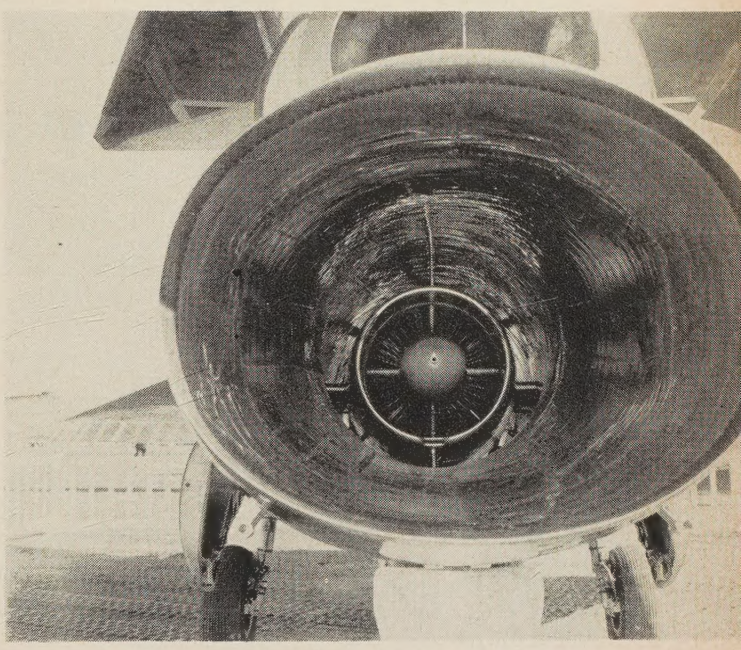


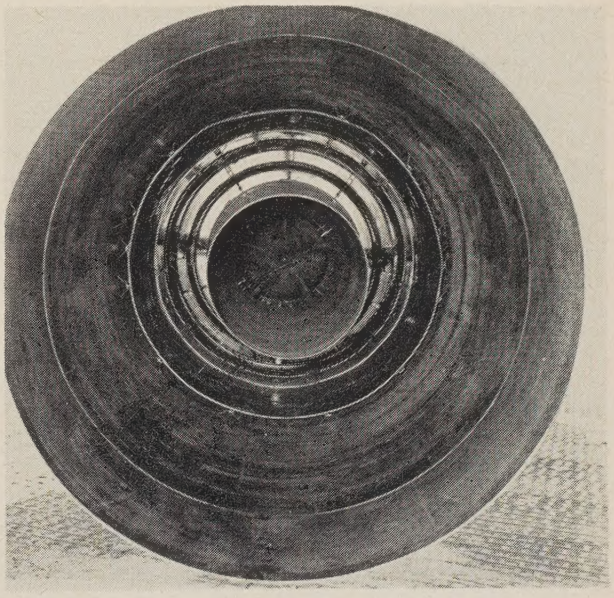
TEST VERSION of Temco's Corvus liquid propellant missile was successfully flown by the Navy. The air-to-surface Corvus is to be used by carrier-based aircraft.

DIRECT CONVERSION of nuclear power into electric energy to propel an ionic spacecraft is foreseen by Lockheed. The reactor would trail a mile behind the vehicle.









INTAKE (top) and exhaust of the turbo-ramjet engine powering the French Nord Griffon fighter. An Atar 101-E3 jet, with 7500 lb static thrust, is housed inside an annular ramjet designed by Nord. The ramjet's fuel pumps deliver 8800 Imp gph. The ramjet fuel system is electronically controlled and has a limiting device for mixture control according to altitude, speed, and control setting. In the tailpipe view, note the ramjet fuel nozzle rings.

◀ **INSIDES** of a ballistic missile nose cone are shown by a full-scale Avco model with a transparent skin. Most of the visible equipment is part of the telemetry and reentry stabilization systems.

R&D systems groups can communicate!

by Lt. (jg) David L. Woods, USNR,
Assistant Project Officer, NARAD Briefing Report, Office of Naval Research

DESPITE tremendous advances in communication by mass media, our means for transfer of information between smaller groups remain rather primitive. Nowhere is this informational void as acute as within modern industry and particularly within the ever expanding area of military R&D.

This communication bugaboo is well documented, although solutions are unfortunately not so prevalent. In July, this department carried a proposal by A. B. Barnes of de Havilland Aircraft of Canada, for general, "unchaired" meetings and increased personal contact between members of systems groups as valid methods for vital exchange of ideas.

My suggestion carries Mr. Barnes' thesis one step further. It calls upon the one mass medium that is equally well suited for the non-mass audience: the motion picture.

To halt some immediate objections, let me say that I am not advocating the elaborate, expensive production, the quip-filled documentary, or the glamorized "Madison Avenue" sales film. Factual visual and audio information can be presented in a simple, straightforward manner in the motion picture.

There are many advantages to films of this sort:

- They are *convenient*—quickly reviewed by an audience, run for a pre-set period, are always available, can give a great amount of data in short period, and are taken easily to any location.
- They are *vivid*—one film can illustrate dynamically progress in many widely scattered places, present individuals from various areas, show actual hardware in compelling action, and approximate visits to several isolated locations.
- They are *effective*—eliminate the "nervous" scientist or engineer, can be revised or updated easily to show project development, are watched in what is inherently a group activity and naturally promote questions and discussion after the showing, and always make the same "approved" presentation.

All these advantages add up to savings in salaries, travel costs, and work time that more than offset the cost of films.

Most R&D companies already have the elements needed for such films in their normal routine on major projects. Some film footage usually is taken, technical data are regularly compiled, and concepts are developed.

However, this material seldom is correlated and combined into a single package. Or, if a film is produced, it all too often is shown only to shop people concerned with the particular project and so loses the great values of cross-fertilization and fresh viewpoints.

All three U.S. military services produce classified color-film briefing reports of about 30 minutes.

Possibly because of funding limitations, the Navy Research & Development (NARAD) Briefing Report fills a communications void most nearly akin to that faced by the R&D industry. The NARAD Report is limited to four films a year. With the primary mission of keeping Navy and Marine Corps officers abreast of R&D progress, these films try to cover both technical and operational aspects of each subject. One subject may have a number of specific projects. The aim is to preset as complete a picture as possible of both project and subject. For, once a topic is covered, it may not be reconsidered for a year or more, if at all.

The NARAD Reports, however, are merely an example for industry. Undoubtedly each company has its own problems, which call for specific solutions. Smaller companies, for example, may convey a great deal of useful information with less complex and less costly films than even the stripped-down NARAD series.

The key thought is that films need not cost more than comparable written reports!

A year of project progress can be presented almost adequately within five minutes. Simple, often amateurish film footage can be blended into an acceptable form.

When a subject is important enough and treated with the proper emphasis, an audience can be held by a motion picture that lacks artistic quality and photographic beauty. Filmed multi-subject R&D briefing reports can be produced by a staff of only two junior line officers and a secretary. (In fact, 2½ years ago, we at NARAD didn't even have the secretary!)

The NARAD series showed that motion pictures can present surveys of up-to-the-minute R&D projects to an appropriate audience. They showed that films can be distributed rapidly to widely divergent areas. A film also insures that the appropriate information will be presented in the same way to all persons. In addition, film reports help to reduce excessive paper communications and technical report distribution, which saves in time and money.

Contributions to this department may be on any subject, technical or nontechnical, about which readers would like to air their views. Names and professional affiliations will be withheld on request.

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